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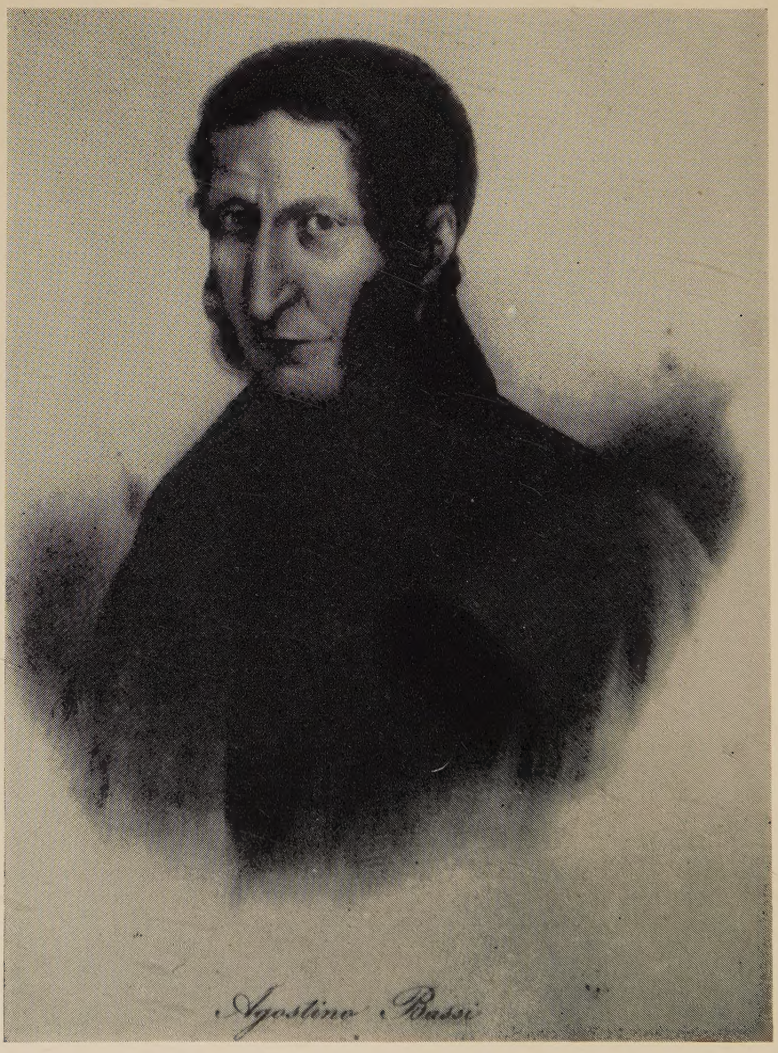
Agostino Bassi

Phytopathological Classics

NUMBER 10

DEL MAL DEL SEGNO

By

AGOSTINO BASSI

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INTRODUCTION

The inclusion of a treatise on a disease of silkworms as a PHYTOPATHOLOGICAL CLASSIC needs explanation. In the past, perhaps even more than to-day, demarcation between one scientific discipline and another was frequently ill-defined. Specialists were less specialized and advances in one field more quickly influenced investigations in others. Bassi, a lawyer turned farmer, wrote lengthily on pellagra and cholera, on diseases of mulberry, vine and potato, and on other topics, but he survives as the first to elucidate the nature of a microbial disease of animals when he proved the fungal nature of the muscardine disease of silkworms by investigations described in a monograph which makes a fitting sequel to Prevost's on bunt of wheat (PHYTOPATHOLOGICAL CLASSICS No. 6).

The principle of pathogenicity is now so familiar that it is difficult to appreciate the novelty of Bassi's work and to understand the opposition it aroused in some. Others accepted the discovery, which was a precursor of those made shortly afterwards by Schoenlein and by Gruby ('the father of medical mycology') of the mycotic nature of human ringworm, and it certainly influenced the Rev. M. J. Berkeley's findings on the cause of potato blight as described in the epoch-making paper which has been reprinted as PHYTOPATHOLOGICAL CLASSIC No. 8 (1948). Bassi was a man of his time. He crystallized ideas that were becoming prevalent and by so doing assured for himself a place in the history of both medicine and plant pathology.

Agostino Bassi was born in Lombardy on 25 September 1773 at Mairago, four miles from Lodi, where he went to school. Later he attended the nearby University of Pavia at which, according to his Autobiographical Fragment, 'he studied law to please his parents, physics, chemistry, natural history, some branches of medicine and the principles of mathematics to follow his own bent'. He was graduated in 1798 and was appointed Provincial Administrator and Police Assessor at Lodi (by the French), later becoming Central Chancellor of the Delegation of the Census. Defective eyesight compelled Bassi to relinquish office and he retired to his father's farm at Mairago where his interest in sheep farming resulted in the publication, in 1812, of his first book, *Il pastore bene istruito* ('The well-educated shepherd'), a comprehensive work of nearly 500 pages. In 1815 he again returned to the public service but after thirteen months was again forced to retire because of his eyes. He then devoted himself to agricultural and scientific pursuits and to writing until his death at Lodi on 6 February 1856.

Bassi's interests were wide and his student days were spent at a University in the van of scientific progress. His teachers included the anatomist

Scarpa, the physicist Volta, and Rasori (1766-1836), the professor of physiology whose book on the living nature of contagion was published posthumously in 1837. Both Rasori and Bassi cannot but have been influenced by the teachings of Lazzaro Spallanzani (1729-1799), the versatile physiologist noted for his studies on spontaneous generation which antedated by a century those by Pasteur and Tyndall. This background must have been an important factor in Bassi's decision to investigate the muscardine disease that ravaged the silkworm industry of northern Italy and France. The progress and outcome of this investigation are set out fully and graphically, if somewhat illogically, in the translation that follows of the first part ('Theory') of the monograph published in 1835.

It appears from the Autobiographical Fragment that his discovery had been made by 1826, and he writes:

> Delighted at having made such a valuable discovery, and being at the time without any means of subsistence[1] and in great need because of the misfortunes which had befallen him, he tried to keep his useful discovery under the seal of greatest secrecy, hoping, not without cause, not merely to free himself from necessity by it but to establish his fortune. He therefore, by means of public news-sheets, invited princes, agricultural and scientific societies and wealthy gentlemen to purchase his valuable discovery; but, giving no credence to Bassi's assertions about a matter which had so long formed the subject of the studies, meditations and experiments of so many savants and famous agriculturalists, both Italian and foreign, no one enquired about his discovery, and several years passed in this way without Bassi's discovery being of use to silkworm breeders. Tired of secrecy in a subject of such importance, and putting the interests of the public before his own, he determined to publish his discovery.

And it was, incidentally, because of the scepticism that greeted his announcement of his discovery, that he eventually, in 1834, submitted it to the University of Pavia and obtained the certificate reproduced in the preface of his work.

Beginning from the notion that the cause of muscardine was 'environmental', that is, was due to the state of the atmosphere, the food, or the method of breeding, Bassi showed that the condition was due to an 'extraneous germ' and concluded that every 'spontaneous' outbreak of that disease could be traced to the introduction of infected silkworms or to the use of contaminated cages or utensils. Bassi did not formally describe the pathogen. This, which was named *Botrytis bassiana* in his honour by Balsamo-Crivelli and later transferred to *Beauveria* by Vuillemin, has a wide distribution and is one of the best-known entomogenous fungi.

The second part of the monograph, which appeared in 1836, dealt with 'Practice'. This is of less general interest but its contents may be briefly summarized.

In the Introduction, Bassi replied to criticisms that had been made of his theories:

---

[1] He subsequently inherited a fortune from a cousin.

> . . . paying no attention, however, to everything that has been said, and may be said, against my principles and practical suggestions out of perversity or other baser passions, which is, it is true, prejudicial to the public interest, but which is inseparable from the human condition, since one cannot silence ignorance, envy and ill nature.

He insists once again, in answer to Balsamo-Crivelli and others, that the muscardine seeds are the cause, and not merely a concomitant, of the disease, and denies the spontaneous generation of the fungus; and he corrects or amplifies what he had said earlier by showing that the living silkworm may be contagious:

> The cryptogamic plant in question . . . must, however, reproduce itself and produce germs, fertile germs, during the life of the victim it has invaded, since many experiments carried out by me this year with the greatest care have proved to me that the silk worm infected with muscardine in the last stage of the disease, i.e., a day or a few hours before its death, is contagious internally, though not externally, and can communicate the disease to other healthy insects and cause them to die, and then to turn hard and efflorescent, if the substance is taken from the internal parts of the diseased insect. By inoculation, however, using matter taken from the living worm, it is difficult to communicate the disease to others, since the point of the needle cannot easily catch the few germs which form and mature earliest; but it is easy if the whole body of the insect which one wishes to infect with muscardine is bathed with liquid drawn from the diseased insect. Perhaps this cryptogam reproduces itself in the living worm from bulbs in the form of tiny grains and then from seeds which it puts forth on the branches which come out and grow on the surface of the insect it has killed. If the muscardine contagion were not present in the reproductive faculty of the mucedine, but in an unknown substance attached to it, injecting the liquid from the worm infected with muscardine ought to communicate the disease even better than the mere contact of the liquid. But the very opposite occurs for the reason indicated.

The body of the Second Part, is, of course, concerned with practical measures for fighting the disease, measures that for the most part follow logically from what he has already said about the characteristics of the fungus in Part I. To prevent the disease from occurring, eggs should be disinfected, particularly if they have been bought, and their containers disinfested or destroyed; uncontaminated and fresh leaf should be used for feeding the silkworms; all contact with contaminated breeding establishments should be avoided (e.g., the windows should be closed if the wind is coming from their direction, flies should be kept out, and their owners should be urged to adopt the measures suggested by Bassi, who continually insists that the attack on muscardine must be a collective operation); the breeding establishment should be well ventilated (it should have large windows, and in order that the air may circulate, there should not be too many tables in a room, nor too many worms on a table); no artificial heat should be used after the third moult; the litter should be changed every forty-eight hours; and in a dry season the floor should be sprinkled with water.

If the disease has already occurred in a previous year, either the attempt to breed silk worms should be abandoned for two successive years, or the rooms should be drastically purified. All wood and paper should

be burnt; implements and mats should be disinfected. The room should be swept, and the sweepings buried and the brush burnt; the person carrying out this operation should have a cloth round his head, and be dressed in a long shirt and stockings without shoes; and when he has finished, these garments, as well as any bedding on the premises, should be boiled, and his hands and face disinfected. The rooms, including the walls, windows, and ceiling, should then be washed down with disinfectant, and fumigated with sulphur. Should the disease break out during the current season, the dead worms must be removed, their trays disinfected, and the hands of workmen disinfected before they touch the leaf or any objects in contact with the silk worms. Infected worms may be cured by being given leaf bathed in disinfectant[2].

During his lifetime Bassi received a number of honours from both Italian and foreign academies and to commemorate the centenary of Pasteur's birth a collected edition of Bassi's writings was published in Italy in 1925 under the auspices of a national committee. One of the few assessments of Bassi's work made outside Italy is that by Major (1944).

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[2] The chief disinfectants suggested by Bassi are chloride of soda, spirits of wine or crude brandy, caustic potash lye, and nitric acid. Implements may also be disinfected by boiling, steam, fire, and exposure to the sunlight.

NOTE ON THE TRANSLATION

Translation is never easy; it always raises the difficult problem, how closely should one follow the original text, and how far should one depart from it, in an attempt to write natural English? Is one, in other words, more likely to be unfaithful to the writer of the original by excessive fidelity or by excessive freedom? But with Bassi, the problem is particularly acute.

His style is bad—as he himself comes near to admitting in the introduction to the second part of *Del Mal del Segno*, when he complains that his critics have often misunderstood him, but adds:

> In developing my ideas, I may perhaps in some places have expressed myself badly.

He is turgid, verbose, repetitive, fond of what Fowler calls "elegant variation" and of stock epithets (the disease is always "cruel", the silk worm always "valuable"), and given to long, rambling, formless sentences. The length of his sentences is in part, one is inclined to suggest, due to his legal training: he is determined to leave nothing unsaid, to cover every eventuality, e.g.,

> un cibo molto più acquoso del solito fornito ai filugelli, e per più giorni, con foglia bagnata dalla pioggia o dalla rugiada, o assai umorosa per qualsiasi altra causa . . .
> (much more watery food than usual being given to the silk worms, and for several days, with leaf soaked by rain or dew, or extremely moist from some other cause . . .)

There are even occasional signs that Bassi himself has lost his way in the middle of a sentence, as when he writes "its" for "their" or uses a singular verb instead of a plural or says:

> Che il mal del segno o moscardino sia realmente d'indole contagiosa, ne sono ormai quasi tutti parsuasi [sic for persuasi], malgrado molti fatti in contrario di cui ignorando la teoria di questo contagio, non sanno i coltivatori rendere ragione a sè stessi di ciò che vedono o sentono dagli altri.
>
> (That the mark disease or muscardine is really contagious in character, nearly everybody is now convinced, despite many facts indicating the contrary which breeders, who are unacquainted with the theory of this contagion, are unable to explain to themselves what they see or hear from others.)

Matters are made worse by the fact that the text is not free from misprints, and that the punctuation is not merely inadequate but sometimes downright misleading.

The translation that follows is as accurate as we have been able to make it; but we have not hesitated, for the sake of the reader, to edit the text to some extent—to alter the punctuation, to break up some of the longer sentences, to suppress some redundant words and phrases, and to omit some of the repetitions. Here and there we have shortened considerably. It may perhaps be as well to give a specimen: here is a fairly typical sentence of Bassi's:

> Lo stato di malattia o qualunque altra causa che tolga o minori od alteri nell' individuo invaso il pascolo alimentante il crudel parassito, oppure che la debolezza o altro difetto di questo, cioè dell'ente contenuto, non gli permetta d'approfittarne per nulla, o ben di poco, sebbene abbondante ed opportuno esista nel soggetto contenente il pabulo, in tali circostanze il germe moscardinico riesce inocuo all'animaletto invaso, se non trova in esso pastura, a non è in grado d'appropriarsela per nulla: o si sviluppa e cresce, perchè si nutre, sebbene di poco, per iscarso, o non opportuno alimento, o per non trovarsi esso in istato di trarne tanto, quanto gliene occorrerebbe onde riprodursi, ed in questo caso il rio parassito, pur vegetando, se non si riproduce, ammazzo però il paziente, il cui cadavere non possede la facoltà di produrre in altri il mal del segno, mancando d'esseri simili a quelli che hanno lui medesimo infermato ed ucciso.

Literally translated, this would read somewhat as follows:

> The state of sickness or any other cause which removes or lessens or deteriorates in the individual invaded the food [literally "pasture"] feeding the cruel parasite, or which the weakness or other defect of the latter, i.e., of the being contained, does not allow it to take advantage of it at all, or very little, although it is present abundant and suitable in the subject containing the food, in such circumstances the muscardine germ is harmless to the little animal invaded, if it does not find food in it, or is not able to assimilate it at all: or it develops and grows, because it feeds, although little, because of scarce, or unsuitable food, or because it is not able to take as much as it would need in order to reproduce itself, and in this case the cruel parasite, although vegetating, if it does not reproduce itself, nevertheless kills the patient, whose corpse does not possess the faculty of producing the mark disease in others, lacking beings similar to those which have infected and killed itself.

In our text, this has become:

> If sickness or any other cause destroys, reduces, or deteriorates the food of the parasite in the insect, or if a weakness or defect in the parasite allows it to make little or no use even of suitable food present in large quantities, the muscardine germ is harmless to the insect attacked. Sometimes under such circumstances it develops and achieves some growth, and so the deadly parasite, which vegetates but does not reproduce itself, kills the victim, whose corpse, however, does not possess the power of producing the mark disease in others, since it contains no organisms similar to those that infected and killed it.

This is an extreme example of our treatment. Most of the text has been treated much less drastically; and much of it has been translated as literally as possible and left unpruned, particularly the Preface and the Conclusion.

We have added a few notes, marked (Translator's Note). All the other notes are Bassi's own. We ought, perhaps, to warn the reader that although some of Bassi's notes are extremely repetitive, many of them are amongst the most interesting and important parts of his book, giving details of his experiments, observations, and theories.

G.C.A.
P.J.Y.

DEL MAL DEL SEGNO
CALCINACCIO o MOSCARDINO

Malattia che affligge

I BACHI DA SETA

E SUL MODO

DI LIBERARNE LE BIGATTAJE

ANCHE LE PIÙ INFESTATE

Opera

DEL DOTTORE AGOSTINO BASSI

DI LODI

la quale oltre a contenere molti utili precetti intorno al miglior governo dei Filugelli, tratta altresì delle Malattie

DEL NEGRONE E DEL GIALLUME

LODI

DALLA TIPOGRAFIA ORCESI

1835

ON THE MARK DISEASE,

CALCINACCIO OR MUSCARDINE,

A disease that affects

SILK WORMS

AND ON THE MEANS
OF FREEING THEREFROM
EVEN THE MOST DEVASTATED
BREEDING ESTABLISHMENTS

A Work

BY DR. AGOSTINO BASSI

OF LODI

Which, besides containing many useful precepts for the better management of silk worms, also treats of

THE BLACK AND YELLOW DISEASES

LODI
Tipografia Orcesi
1835

PREFACE

The cultivation of the mulberry has almost reached the pitch of perfection, and the breeding of silk worms would be no less advanced, so that it would be possible to say that he who has mulberries has silk in proportion to the amount of leaf he owns, were it not that the terrible mark disease or *calcinaccio* constantly opposes the breeder's efforts, and frustrates all his attempts to prevent or overcome it. It is amenable to no remedy and is contagious in character, and the number of its victims increases annually, and must of necessity increase as its contagious germs increase; these are minute, and cling fast to all bodies and even remain suspended in the atmosphere, contaminating in this way the very air of the breeding rooms. But if the mark disease has been able hitherto to cause so much loss both to private citizens and to the state, it was because neither the enemy to be combated nor the ways and means of attacking it were known.

Now, however, that the principle giving rise to the terrible disease has fortunately been discovered together with the means of preventing and curing it, if it does not entirely disappear from our silk worm establishments (nature is too powerful to allow even her noxious products to be destroyed completely), at least it will cease to wreak havoc among the valuable insects. The book which I am now giving to the public reveals the substance or principle which causes the disease, its nature, the various ways in which it enters silk worm establishments and is spread, how one can keep it away from the breeding rooms, destroy it when it has got into them, and stop it from reproducing itself and spreading to the surrounding objects, thus preventing the disease and stamping it out when it has appeared: it also reveals all the circumstances which favour the development of the disease, as well as those which hinder it. The work deals, too, with the yellow and black diseases, with particular reference to the manner in which these diseases spread independent of the original cause which gave rise to them and to the ways of checking their spread. I have divided the work into two parts: in the first I expound the theory, and in the second I deal with practical measures.

The truth of my discovery I proved by experiments carried out before a commission of nine professors of the I. R.[1] University of Pavia, which delivered the following certificate[2] to me.

= In 1833, Dr. Agostino Bassi of Lodi applied to the I. R. University of Pavia for permission to communicate some experiments and discoveries of his concerning the so-called mark disease of silk worms. But since the appropriate experiments could not take place that year, he repeated his request in the current year, 1834: and when the experiments had been performed in the presence of a Commission consisting of members of the

Faculties of Medicine and Philosophy, the following conclusions were reached:

1°. The white substance, crust, or efflorescence on the silk worm is indeed contagious and hence liable, if it is in any way brought into contact with the healthy insect, to cause and spread the disease.

2°. The efficacy of the substance can be destroyed by various chemical agents, harmless to the insect, either before the substance is applied to the insect's body, or after it has touched it, providing that the application of the remedy quickly follows contamination.

3°. In view of the great ease with which this contagious substance spreads—it rapidly takes hold of everything and clings firmly to it; and in view of the extreme minuteness of its particles, which is such that one single dead worm, after the efflorescence has appeared, can contaminate a whole breeding establishment: it cannot be doubted that it is a common cause of this disease.

4°. In view of the fact that there are chemical agents which can decompose and destroy this disease-bearing substance, the commission is convinced that, by the opportune use of these agents, it will be possible to control the spread of the disease, which at present takes place too easily, and even to cure and prevent it as well.

CONFIGLIACHI, *Pro-Director of Philosophical Studies and Professor of Physics.*
MORETTI, *Professor of Agriculture and Botany.*
BRUGNATELLI, *Professor of General Universal History.*
PINALI, *Pro-Director of Medical Studies.*
DR. PIETRO CARPANELLI, *Dean of the Faculty of Medicine.*
DR. GIAMBATTISTA LAURIN, *Professor of Veterinary Science.*
PLATNER, *Professor of Medical Police*[3].
DE CATTANEI DI MOMO, *Temporary Professor of Chemistry.*
GIAMMARIA ZENDRINI, *Professor of Special Natural History.*

I certify that the signature and the status of the following are genuine and correct: Drs. Pietro Configliachi, Ordinary Professor of Physics; Moretti, Ordinary Professor of Botany and temporary Professor of Agriculture; Brugnatelli, Ordinary Professor of General Natural History; Pinali, Pro-Director of Medical Studies; Pietro Carpanelli, Dean of the Faculty of Medicine; Giambattista Laurin, Ordinary Professor of Veterinary Science; Platner, Ordinary Professor of Medical Police; De Cattanei di Momo, Temporary Professor of Chemistry; and Giammaria Zendrini, Ordinary Professor of Special Natural History in this I. R. University.

Pavia, August 30th, 1834.

Dr. CESARE RIPARI, *Registrar.*

My book should be of interest not only to the breeder of silk worms, but to all students of the natural sciences, since it may perhaps resolve some of the many anomalies which the doctrine of contagious disease in general contains, and by diffusing new light bring the dawn of new discoveries in a field which is so important and still so obscure.

Having been compelled by the force of circumstances to recast my whole book in a short space of time, I have nevertheless not been able to give it the arrangement and logical sequence I should have liked. But the majority of my readers, and especially those who are most interested in the subject, may possibly be grateful to me if they find the same principles repeated in several parts of the book. Subsequently I or others more fortunate than I may expound the same doctrine with more fitting method, wider learning, and a more elegant style.

For the rest, I beg the savants and the more lettered silk worm breeders to have the goodness to communicate their observations on it to me. I warn them, however, that to save time and trouble I shall only reply to those which seem sufficiently founded in fact to further in some way the advancement of science or technical skill.

Furthermore, I beg those who are so kind as to check my experiments to repeat them over and over again for several years without ceasing, even though they sometimes in certain circumstances obtain results contrary to what they expect for causes unknown to them and perhaps still unknown to me. It is always necessary to base one's calculations on the large number of similar facts, until time makes known to us the reasons which have caused a few of them to depart from the established principle.

Having learnt the present theory of calcification, the reader will be in a position to repeat the experiments on which I have based it, to carry out fresh ones, and perhaps even to find more effective or more rapid or more economical means of banishing the muscardine scourge than those which I propose.

Since there is almost no test which I have not carried out, anyone who, before undertaking the experiments mentioned and other ones, would take the trouble to communicate his ideas to me beforehand might gain some preliminary notions which would save him no little time, expense, and labour, and thus considerably hasten acquisition of the knowledge of the truth.

The author's attempts to make the mark disease or calcinaccio arise in the silk worm spontaneously, and their results.

Having become aware, as early as 1807, of the havoc wrought by the mark disease, muscardine, *calcinaccio*, or *cannellino*, in many places, particularly in high districts, and having moreover read of the vain endeavours of several distinguished minds, both Italian and foreign, to discover the true source of the terrible disease and to find reliable ways of preventing or banishing it, I had a mind to attempt this difficult undertaking, too, to see if it were possible to free the breeders of these useful

insects from the heavy toll which, to our shame, they pay every year to ignorance, in a century in which all the sciences, and especially the natural sciences, have risen so high. And being convinced that the disease arose spontaneously in the silk worm and was due to some difference in the atmosphere, the food, or the method of breeding, or rather to the various fumes emanating from the fermenting litter, I thought that I might succeed by reiterated experiments in developing it by artificial means as well.

I therefore bred silk worms in all ways, even subjecting them to the most barbarous treatment: the wretched creatures died by thousands and in a thousand ways, but none of them could be preserved from putrefaction after death. All their corpses decayed sooner or later, and not one was saved from corruption or turned hard, still less was calcified with efflorescence. I continued these experiments from 1808 to 1813, wasting money and journeys and labour in vain, without ever in the least succeeding in my purpose, and I was amazed that, while nature slaughters the valuable creatures on so large a scale under our eyes, it was not given to man to kill even a single silk worm by the same means.

It was then that,—as I reflected that, as the silk worm passes from the larva or caterpillar to the chrysalis, and thence to the moth or perfect insect, it gets rid of liquid substances, gradually loses its moisture, and gains more and more consistence, and that this change or alteration in its density can be due only to the acids, the earths, and the alkalis present in it, which combine chemically with each other to form salts which then constitute the solid parts of the insect,—I began to suspect that the mark disease was produced in the silk worm by an excessive proportion of acid substance introduced into the insect or generated in it by some cause. This idea had already occurred to other silk worm breeders and writers, particularly our own celebrated and meritorious Abbot[4], who presented the public with the best precepts which could be provided in his day in the difficult art of tending the valuable insects. And since the silk worm which has died of muscardine turns hard and is preserved from corruption by virtue of a phosphate which solidifies it inside and covers it on the outside with a thick layer of saline substance, the first idea which occurred to me was to test phosphoric acid, as he suggested to the members of the Paris Academy. But having used the purest phosphoric acid, both introducing it into the silk worm with its food and moistening the whole surface of its body with it, I obtained the same results as those scientists, i.e., no hardening of the corpse, no efflorescence.

These attempts having also failed, I carried out fresh experiments, using earths and phosphoric acid simultaneously, and I found that the corpses of the worms into which I had introduced these substances with their food were preserved from putrefaction or decayed much more slowly than the others. Then I used impure phosphoric acid obtained from bones which still contained a residuum of lime in the same way, and sometimes the same acid in its pure state with a little lime added, and I was satisfied

with the result produced, particularly as regards those silk worms to which I applied it externally, that is to say which I moistened with it several times until they perished. When they were dead, their corpses remained uncorrupted like the worms killed by *calcinaccio* and almost as white, but not equally hard, so that the similarity between them and the true calcified worms was not perfect.

I then tried in various ways to reduce the aqueous principle in the silk worm so as to increase the proportion of acid, earthy, and alkaline substances in it: but by none of these processes was I ever able to obtain a truly calcified worm. At last, continuing my experiments in all possible ways, I obtained really impressive results in the following manner.

I hung little paper bags, each containing a large silk worm near maturity, at various heights in the chimney of a fireplace in which a fire was burning continuously. When, after several days, I opened the bags, first those which had been exposed to the greatest heat, then the others, I found several that were solid and hard like calcified worms. I maintained a given degree of moisture on the surface of these by putting some in the cellar and placing the others under small glasses, taking care to wet the surface of these last every day: under these conditions, some became covered with a white eruption exactly similar to that found on muscardined silk worms; and, since they were as firm and hard as these, they had all the appearance of true calcified worms, and a large number of silk worm experts to whom I showed them without saying anything of their origin, judged them all without exception to be true calcified worms.[5]

I no longer doubted the spontaneity of the disease, and I at last thought I had scored a bull's-eye and was glad to have discovered that the muscardine disease or *calcinaccio* really came from an excess of acidity in the worm, whatever might be the cause that had produced it, when, comparing the characteristics of my calcified insect with that produced by nature, I could not help noticing, to my inexpressible grief, that the former lacked the essential characteristic that marks the true muscardined worm, indeed the only property that can distinguish it from all the others that may exist with exactly similar appearances, i.e., it lacked the power of contagion—that of communicating the disease to other insects: since, when my dead silk worms which had turned hard and white were placed in contact with healthy, living silk worms, not only did they not produce a single muscardined or calcified worm, but they did not make even a single worm fall sick, and always proved completely harmless to them, whereas the silk worms calcified by nature, if used in the same way, always produced sickness, death, and calcification.

This event cast me into the deepest dejection. I looked on the cause of the dreadful *calcinaccio* as covered by an impenetrable veil, and I despaired of removing it from the darkness to the light of day: it appeared to me to be buried in the blackest night. Humiliated in the extreme, silent and idle, I wept over my lost laurels and bitterly lamented the adverse fate which had put me to so much study, expense, and labour in vain. It was

the year 1816: oppressed by a terrible melancholy, which had already beset me for many months in various ways and from different directions, I found the courage one day to shake off its yoke, and, challenging adverse fortune once more, I began to interrogate nature afresh in various ways, with the firm resolve never to abandon her until she had been tamed and answered my questions honestly.

Having failed by so many different processes to produce muscardine in the silk worm except by the use of the true calcified worm, it occurred to me that it did not originate spontaneously in the insect, and that it needed an extraneous germ which entered the insect from outside and caused the disease; and I resolved to search for this deadly being, to discover its nature and habits and all the ways by which it enters silk worm establishments and makes its way into the worms, infecting them with the dreadful disease, and, what is more important, to find, if possible, a means of preventing the disease from developing by stopping the contagious germ from entering both breeding establishments and silk worms, or by killing it as soon as it has entered them, or at least checking the disease when, unfortunately, it has appeared, so as to prevent the heavy loss that it so frequently causes to the breeders of the useful insects, and through them to the state at large.

FOOTNOTES

[1] = Imperial Royal: a reminder that Lombardy was then under Austrian rule. (Translator's note).

[2] A facsimile of this certificate is given in Belloni, *Documenti Bassiani*, 1956. (Translator's note).

[3] We are indebted to Dr. F. N. L. Poynter, Librarian of the Wellcome Historical Medical Library, for the following note:

"The term 'Polizia medica' was coined by the great Johann Peter Frank and was adopted in English as 'Medical Police' which is actually the title of a book by John Robertson published at Edinburgh in 1808-9. It means public health in its widest aspects and includes the duties of Medical Officers of Health, quarantine officers, etc. Platner was actually professor of forensic medicine *and medical police*". (Translator's note).

[4] i.e., Spallanzani. See introduction p. ii (Translator's note).

[5] The hardening and subsequent preservation of the dead silk worm is due in this case, I think, to the action of the oily volatile principle present in soot, which was discovered by Herr Reichenbach and by him named creosote.

PART I
THEORY

CHAPTER I

The mark disease, muscardine, calcino, calcinetto, calcinaccio, or cannellino.

Generally speaking, the silk worm affected by this terrible disease gives no sign of suffering from this or any other illness: indeed it appears to be in good health and full of vigour. The only signs of discomfort shown are that it becomes slower in its movements and ceases to take food when it is near death. Otherwise it keeps all the appearance of health, its natural colour and its size; and when it dies it preserves the semblance of life, so that it is often necessary to touch it to make sure that it is dead. Only occasionally does it turn red shortly before dying and exhibit reddish, livid, and yellowish blotches dispersed here and there over the surface of its body. This phenomenon, however, is rare, and I witnessed it only a few times in all the many batches of silk worms stricken with the disease which I observed, and in all the many experiments I carried out on this subject: it generally occurs in the most violent epidemics.

When an insect has died of the mark disease or muscardine, its corpse, from being soft, flabby, and impregnated with liquid substance as it is at first, soon takes on greater consistence; the humours coagulate, and it becomes more and more solid and hard, until it is dry, brittle and like glass. Before the corpse solidifies—indeed usually as soon as the humours have coagulated and the dead insect has taken on a little consistence—the majority of the silk worms that have died in this way turn red; others preserve their natural colour; and there are even some that assume a deep blue colour, according to the different varieties of the principle that causes death and the subsequent hardening, as we shall see later.

Then all the worms that have perished from the disease, except that which has perished of the black muscardine disease or the spurious mummy, of which I shall speak later, are liable to turn more or less white, i.e., to become covered with a patina or efflorescence like flakes of pure snow, unless they lack the necessary moisture, as I shall show in the following chapters.

Silk worms speckled with the blotches mentioned above having been seen to die, turn hard and then become calcified, the disease from which they perished was called the mark disease; and from the white patina or

crust which normally covers the corpses of insects that have died from the disease, they came to be known as *moscardini, zuccherini,* or *cannellini,* because of the resemblance of the calcified insect to certain sweetmeats of the same shape.

The disease attacks the silk worm at all ages and at all stages—in fact, all its life—from about 7°R. up to 30°R. or more. At higher temperatures, i.e., at about 38°, and still more with greater heats, the principle that causes *calcino* loses its power, and the disease consequently does not develop, or, if it has already started, does not progress.

The mark disease or muscardine is not a result of the state of captivity to which man has brought the silk worm: it exists in nature, and is perhaps as old as the silk worm itself; it attacks not only this insect, but several other species of grub also, even all perhaps, in their natural state of freedom[1].

FOOTNOTE

[1] I have found calcified caterpillars of the Dispar moth on willow trees in the open country, and others of the common Caruga in the ground; and other caterpillars, also calcified, of the same moth as well as the Atropos and other insects, have been seen in the open country by our eminent Dr. Enrico Morandini, the director of the Spedale civico maggiore. And these and other caterpillars, moreover, can be calcified at will, as caterpillars, chrysalises, and moths.

CHAPTER II

The mark disease, calcinaccio, or muscardine, is a contagious disease. An insect suffering from it, however, cannot communicate it to others so long as it is alive. It becomes contagious when it is dead.

The contagious principle develops in the living insect and reaches perfection in the corpse. But even the corpse of an insect that has died of true muscardine is not always contagious.

The contagion is communicated by food, by inoculation, and by the mere contact of insects that have died of the terrible disease, of any infected object, and even of air contaminated by the disease-bearing germs. These are so abundant in a single calcified or efflorescent insect, and so minute, that they spread with extreme rapidity and in infinite numbers, cling fast even to the smoothest and most polished objects, such as glass, metal, etc., and even rise up into the air which they partially infect so long as they remain suspended in it.

The disease is not peculiar to the silk worm, but may arise in other species of caterpillar, perhaps in all. It can be transmitted artificially to other insects in the same way as it can be communicated to the silk worm, and produces the same effects in them: and if the contagion passes from them back to silk worms, it is always identical, and never in the least alters its nature or its behaviour[1].

The fatal muscardine germ, however, even though it makes its way into the insect and kills it, does not always succeed in reproducing the disease, so that the insect that is invaded and killed does not necessarily acquire the power of communicating the disease to other insects.

All this will be fully discussed in the next chapter and the following ones.

FOOTNOTE

[1] I possess several sorts of grub which I have calcified—grubs of the Dispar moth, of Pavonias, of Rodilegno [probably the goat moth] or *cossus ligni perda* of Carugas, of various Sphinxes and other species of insects, which I am always willing to show to anyone who would like to see them. From these mummies one can extract the germ or principle with which the mark disease, death and subsequent calcification can be caused both in the silk worm and in other caterpillars, without the fatal agent's ever losing its original contagious virtue or growing less powerful as it reproduces itself over and over again, even in insects of a different species.

One can infect caterpillars artificially, merely by touching them with the point of a needle, after extracting the contagious principle from calcified insects or from objects infected by them, by touching the substance on which they feed, or by inoculating them with the disease-bearing substance. This can be done by pricking or piercing their skin with a pin, whatever stage they are in, whether caterpillars, chrysalises, or butterflies.

If the muscardine disease is communicated to several insects at the same time and under the same conditions in the three ways mentioned, i.e., by inoculation, by contact, and with food, normally the inoculated ones are the first to die, then those merely touched, and last those infected through their food.

CHAPTER III

The mark disease or calcinaccio never arises spontaneously in the silk worm, and the same is true of other insects attacked by that disease.

It was in vain that all these distinguished men of several nations laboured to make *calcinaccio* or muscardine arise spontaneously in the silk worm; and I too carried out all possible experiments with the same object, as I have related, always to no purpose. I tended the insects in many different ways; I inflicted the cruellest treatment on them, and used several kinds of poisons, mineral, vegetable and animal; I employed irritant, corrosive, and caustic substances, now simple, now compound; acids, alkalis, earths, and metals, in short the most noxious substances, deadly to the animal organism, in the solid as well as in the liquid or gaseous states; but everything proved useless for my purpose. There is no chemical substance nor any product of the perverted animal economy which can cause the terrible muscardine in the silk worm or in other caterpillars.

From 1808 up to the present, I observed a very large number of silk worm establishments stricken by the cruel *calcinaccio* and I noticed almost everywhere that the terrible disease began in the same year or the year before with a few insects, and increased steadily until it became widespread.

In some places the disease had suddenly assumed the character of an epidemic, so that it really seemed to have arisen spontaneously: but when I had thoroughly examined all the circumstances and ascertained the facts, I almost always concluded that the disease was caused by contagion, i.e., by the infection of the eggs, or by the use of contaminated tables or other articles, or by contact in one way or another with infected persons or objects or with infected establishments in the vicinity.

In other establishments I sometimes noticed that the disease seemed to have spread rapidly, killing a very great number of old silk worms in a short space of time. However, when I had looked into the previous course of their development, I saw that the muscardine had been present on a small scale from the very beginning, and that, because of the small size and number of the insects calcified, it had managed to remain concealed from those who were not on the watch for it.

Finally I observed that, while the silk worms in one room were dying in large numbers, none or very few died in a neighbouring room, although the method of management, the food and every other circumstance were identical: and that for no other reason than that no muscardine germs, or very few, were present in one room, whereas they were present in large numbers in the other. The mark disease or muscardine, therefore, never arises spontaneously. I shall return to this question in the last chapter of the first part of this treatise.

CHAPTER IV

Calcino or the mark disease is always caused by an external organism, which enters the insect and produces the disease, death, and the subsequent hardening and efflorescence of the corpse.

We have seen that no product of the living body or of the perverted animal economy, no simple or compound substance, whether of the animal or vegetable kingdom, is capable of causing the disease. The organism that I am about to describe alone has the power of achieving this result. This murderous creature is organic, living, and vegetable. It is a cryptogamic plant, a parasitic fungus[1]. It feeds only on animal substance, vegetates and propagates itself only in larvae, and germinates only in the living insect, never in the dead one, as I shall explain fully later. It is indeed singular that while it needs the life of the individual it has invaded to develop and grow and hence to become capable of reproducing itself, it does not produce its fruits or seeds, or at least it does not mature or fertilize them until after the insect which has received it and fed it is dead.

The insect that contains it, consequently, is not contagious so long as it is alive, since it lacks germs or seeds or at least viable seeds. The corpse

alone possesses the power of contagion, but not at all times nor in all circumstances.

The seeds of the deadly fungus, entering the silk worm (and the same is true of other insects) germinate; the plant feeds and grows; and, as it grows and expands, it kills the creature it has invaded[2] and then produces its fruits, or if they have already been produced, matures or perfects them in the corpse, in the dead substance of which, the opposing force of life having ceased, the parasite finds all the food necessary for its complete development[3].

Only a corpse, therefore, containing germs similar to those which deprived the insect invaded of life can communicate the disease to other insects and bring them to the same end, as we shall see later.

When the victim has been killed, its body, soft and elastic, and like a bladder full of water, soon begins to thicken, the humours contained in it coagulate, the corpse turns red[4], it becomes more solid and harder, and, if there is sufficient moisture, it becomes covered with a mould or white efflorescence, like pure snow, which is nothing but a forest of fungi, i.e., of the little parasitic plants which have brought about the death, the hardening, and the subsequent calcification or efflorescence.

These tiny plants, which were already present and developed inside the dead insect, come out, if they can, on to the surface of the body, piercing its skin; and the less the resistance that the skin above them offers, and the greater—up to a certain point—the moisture and the temperature of the surrounding air, the more luxuriant they rise above it.

Then these tiny plants gradually lose water and, as they dry, are converted for the most part into a fine dust that contains the abundant seeds of the parasitic fungus together with the debris of its stems. These seeds or germs, which are light, abandoning the body in which they came into being at the slightest movement of the air, spread in large numbers over all the surrounding objects, and even into the air itself, which they permeate and contaminate as long as they are suspended in it. The damper the atmosphere of the silk worm establishment at first while the fungous plants grew, in other words the more thickly and vigorously they fructified; and the drier the air in the breeding room subsequently became, in other words the more quickly and abundantly the contagious germs were spread—then the more rapidly and thickly they are scattered. These disease-bearing germs, however they enter other insects, i.e., other caterpillars, cause the same disease, death, the hardening of the dead body, and the subsequent calcification or efflorescence in suitable circumstances.

If these germs enter the insect, and grow inside it, but, from some defect in themselves or in the creature they have invaded, cannot reproduce themselves, their growth does, it is true, kill the victim, but in this case its dead body turns black and cannot cause the mark disease, because it lacks the muscardine germ. It is nevertheless capable of causing death in other insects, but by another kind of disease which I have called black or gangrenous, and of which I shall also speak in the present work[5].

The damper, the warmer, and the more stagnant the air surrounding the insect which has died of *calcino*, the denser, the taller and the more luxuriant the little parasitic plants grow on the surface of its dead body, which quickly becomes covered all over with white flowers, like flakes of pure snow, and like white down, if growth attains the maximum degree of vigour[6].

The fresher, drier, and colder the air that touches the dead insect, on the other hand, and the more deficient the insect is in moisture, the less vigorously the little cryptogamic plants develop on the corpse. And if, moreover, the air that surrounds it is very dry or if the body contains very little liquid, and particularly if both these circumstances obtain, then the parasitic fungi do not turn the surface of the corpse white, and sometimes do not even succeed in piercing the skin, if it is too hard by nature or because of excessive dryness.[7]

The silk worm that has died of genuine *calcino* and that does not turn white, or the genuine mummy that does not effloresce from lack of moisture or because of the dryness of the surrounding air, or from both these causes together, is not necessarily devoid of the contagious virtue. It still possesses it inside, if it does not lose it for extrinsic causes, and it is almost always contagious outside, too, since the deadly parasitic fungus still generates and matures its seeds in the internal parts of the insect that contains it, although, for the reasons mentioned, it cannot turn the body white by growing on its surface or even pierce its skin. In the latter case alone, the dead insect is not contagious on the surface of its body—though it is contagious internally—from lack of disease-bearing germs outside. The seeds, however, that form and mature inside the dead insect are less virulent and have a shorter and less tenacious life than those that reach their full development externally, coming from robust and well constituted parents. The only difference between the mummy without the efflorescence and that which has turned white is that the former, besides containing, as I have said, less active and less durable germs, scarcely contaminates, or does not contaminate at all, the various objects and the air around it, since the new muscardine seeds reproduced are either not present on its surface, or present in small numbers, or present but clinging fast to it, like those that are less mature and less developed inside the parent plants.

The contagious germs or seeds are provided by the exanthematic, i.e., the white efflorescence that appears on the insect that has died of muscardine and then turned solid; this substance is the same parasitic plant at its maximum development, carrying its own seeds which cause the deadly disease and the subsequent calcification. The same seeds or germs are also supplied by the dark points on the body, i.e., those that have not turned white, whenever the little parasitic fungi beneath have pierced the skin above, even though no exanthema or bloom appears on them, at least if the dead insect is observed with the naked eye: but they are only few in number and always less active than the others, as I have said, and can

be killed more easily and more quickly. They may be supplied also by the internal parts of the dead insect, but these can only be obtained by artificial means[8].

Even the silk worm which has died of true muscardine does not communicate the disease to others at all times or in all circumstances. It does not normally transmit it immediately after death, sometimes not even by inoculation, even if the needle is plunged inside the corpse; and sometimes it is not even contagious by simple contact, since it has as yet no contagious seeds or germs on the surface of its body, or if it has, they are not yet mature, or are so rare, that, if it is placed in contact with other insects at some points only, it is unlikely that they can pick up or touch these disease-bearing germs. It is not contagious internally either, for the same reason, that there are as yet no fully-developed seeds there, or the seeds are still sterile, or, although they are mature, they are, nevertheless, so few in number as to be unlikely to be picked up by the point of the needle plunged into the dead body. Hence, both mere contact with the surface of the dead body, and inoculation with matter taken from inside it as above, usually turn out to be harmless at that stage[9].

Sometimes the germs that are touched on the outside of the dead body, or inside it with the point of the needle as above, being insufficiently developed to be able to reproduce themselves if they enter living creatures, but capable, nevertheless, of vegetating, cause the muscardine black disease or spurious mummy.

Whether covered with efflorescence or not, the corpse of an insect that has died of muscardine cannot communicate the disease whenever, for any cause or agent, the disease is extinct in it, or the disease-bearing germ has become incapable of development because it has been killed or weakened to such an extent that, although the latent life is not entirely extinct, it is, nevertheless, no longer able to become active[10].

Similarly, the dead body or the mummy, the surface of which is not covered with efflorescence, is sometimes not contagious when the skin of the dead insect is so hard because of particular circumstances, as sometimes happens with chrysalises, that the parasitic plants inside, being unable to pierce it, cannot therefore carry their seeds to the surface of the body of the dead insect.

The muscardine disease, i.e., the seed of the deadly fungus, is more quickly and more easily killed in the body or while adhering to the body of the insect in which it was produced than when it is separated from it since the slow dissolving ferment which begins and continues, though imperceptibly, even in the genuine muscardine mummy, makes the disease-bearing germ grow weak and die more quickly: the contagion remains active longer in the whitened part of the corpse, where the contagious seeds are more plentiful and more mature, than in the dark part; and when there is no longer any contagion there and inside the dead insect, it is still found on the stems or filaments of the deadly plant, which were elevated on the dead body by a growth rendered luxuriant by favour-

able circumstances. That fact also proves that the disease-bearing germ is present in the plant or organic production, rather than in the animal substance of the dead insect, as some might suppose. I shall discuss this at the end of this theoretical part, in Chapter VIII.

If a corpse that has turned white and dry is shaken over water, the muscardine seed or dust that falls on to the liquid is so light that it always remains on its surface, without ever sinking, and it remains still active or contagious for some months: and if it is submerged in the water by some means, it nevertheless remains unimpaired for many days, whereas, if the corpse is immersed in the same liquid, it very soon, by decaying, loses all its power of communicating muscardine. Nevertheless, if a worm that has just died of the mark disease and that is still soft, or has even acquired a degree of consistence is placed in water and left there for many hours, even sometimes until it stinks a little, yet, since the parasitic plants inside are at their maximum vegetative vigour, above all in their period of reproduction, they still subsequently cause efflorescence on the surface of the corpse, even though the slight stench which it sometimes has, shows that the process of putrefaction is already advanced: and if the efflorescence is touched, it still communicates muscardine, like the plants that contain their seeds mature and as yet uninjured.

As the muscardine seed or dust spreads in the atmosphere, all objects that enter air which has been permeated, including water and other harmless liquids, may be contaminated and communicate the infection to the silk worms, and particularly to those in direct contact with the air itself.[11]

If the white crust or efflorescence that covers the worm that has died of *calcinaccio* is due to the development of the parasitic fungus, the coagulation of its humours, its turning hard and its mummification are also in origin a result of the growth of the same cryptogamic plant. When the death of the insect attacked by muscardine has occurred, an acid substance appears in the corpse and gradually decreases and disappears altogether as the corpse subsequently turns hard and dry. This acid, which must be phosphoric acid, seems to be generated or released, if not wholly, at least mainly, at the period of formation of the seeds of the parasitic fungus or of their fertilization. But whatever the period of the genesis of this substance or the manner in which it is formed or released, it is certain that it is a product of the same organism as causes the mark disease, since it is not present in other silk worms that have died of other kinds of disease, or from any other cause, just as it is also certain that this acid is the cause of the hardening and preservation of the dead insect. Entering into combination with the earths and with the alkalis present in the corpse, it forms salts or phosphates, which, whether they form part of the immediate materials of the parasitic vegetable, or whether they exist outside it in the remaining animal substance of the dead insect, help to turn the corpse solid and to render it incorruptible by separating from it, as they form, the aqueous principle, which then

evaporates, so that the corpse grows smaller and smaller and harder and harder.[12]

There are several varieties of the parasitic plant or fungus that kill the valuable insects. They differ in vigour of growth and in colour. There is one whose seeds germinate, feed, and reproduce themselves less easily and more slowly, and have a less tenacious and a shorter life, than those of the common or more malignant variety.[13] There is another that never turns the silk worm attacked by *calcino* red or any other colour, either alive or dead, although it clothes it in due course and in favourable circumstances with the usual white covering, just like the other silk worms killed by the same disease, and the worm preserves moreover all the other characteristics of the true muscardine mummy, even rusting the needle, exactly as the red corpses do. And another has also been seen that turns the silk worm which has died of the mark disease deep blue, instead of turning it red or leaving it its natural colour.[14]

The active existence of these muscardine germs or seeds, has however a limit, as all organic beings have, beyond which it is not given to them to exercise their contagious power. Usually their latent life, and with it consequently the contagious power, becomes extinct before they are two years old, so that in the second brood of silk worms after that in which these germs were generated, their presence is harmless. In high districts and in dry ones, however, they sometimes go beyond this period: and in well-watered or otherwise damp ones they seldom or never attain the second year of their age and generally die before the generation of silk worms following that in which they originated, or if they do live, they are already so weak at that time, that normally they can scarcely reproduce themselves, and if they enter the silk worm they turn it black instead of calcifying it, for reasons that I shall explain later, especially if the germs or seeds belong to the least vigorous variety. If these germs or seeds are well preserved, however, in the way that suits them best, they can remain active or contagious for a period of nearly three whole years, as several of my experiments show.[15]

FOOTNOTES

[1] The eminent and meritorious compilers of the celebrated Giornale Fisico-Chimico, Professors Configliachi and Brugnatelli were the first to put forward the hypothesis that the mark disease is produced in the silk worm by the development of a species of fungus, basing it on the fungus-like smell that comes from worms which have died of that disease; and although, in that journal, they appealed to breeders to undertake experiments to test this supposition, these last, perhaps regarding it as the figment of a heated imagination, neglected it, whereas, had they taken the trouble to examine it, they might easily have found, by experiment, that these able men were not mistaken and had really hit on the truth.

[2] From my various observations and experiments, which, in order not to be too prolix, I do not describe, it appears that the little plants developing from seeds entering the insect in any way at all, besides their individual growth, also spread or multiply in the living insect by branching and ramifica-

tion, not bearing fruit, or not bringing the fruits or seeds already formed to maturity, until after the death of the insect.

[3] Although, after establishing itself, the parasite gradually breaks up the invaded insect, until it mortally disturbs the animal economy and extinguishes life, it displays its greatest activity after the death of the poor creature which nourished it, when, its vital power being extinct, the deadly plant can obtain all the nourishment necessary for the full development of its fruits. It is at this period that the greatest changes take place in the substance of the dead insect, which is almost entirely assimilated by the organism that has killed it. The efflorescence, the white substance that covers the calcified worm, is a heap, or rather an aggregation, of the little parasitic plants, which as they increase, grow, when they can, on the outer surface of the animal inside which they came into being.

[4] The corpse does not always turn red, as I shall show later.

[5] Since the production of the so-called mark disease, of the death and subsequent hardening and preservation of the insect invaded, is the work of the vegetative act, or rather of the vital faculties of the parasitic plant, that plant cannot become contagious, in other words cannot produce the same effects in other living creatures, except by reproducing itself, which it does, as I said before, by means of seeds. But in order that all the events mentioned—namely the disease, death, and subsequent calcification—may take place, it is not enough for the seed or germ of the parasite to alight on the body of the insect; it is also necessary for it to enter it and develop, grow, and reproduce itself there. If it enters and does not germinate, or if it germinates but does not vegetate and increase, its presence is harmless to the insect invaded: and if, having entered and developed, it feeds and grows, but does not reproduce itself, it does, it is true, kill the worm that contains it, but it does not harden, calcify and preserve the corpse from corruption. To cause the disease, the death and the subsequent hardening and the conversion of the dead creature into a true mummy, it is necessary for the germ to make its way into the insect, to feed, grow, and reproduce itself. If it only develops, vegetates, and increases, but does not reproduce itself, or produces only imperfect organisms, namely ones not endowed with the procreative faculty, either from a defect in itself or in the insect that contains it and that offers insufficient or unsuitable nourishment—then the body of the dead insect does not become solid, does not turn white, is not preserved, and remains quite incapable of producing the same disease as killed it, being without muscardine seeds, or containing only barren ones, or lacking germs equipped with the same virtue as those that attacked it and killed it, i.e., the procreative power. When, however, putrefaction has begun in the dead body, other contagious germs which I have called black (negronico) or gangrenous, are generated in it, which, if they enter the silk worm or other insects, kill them unfailingly and with great rapidity, as we shall see at the end of this work, in the practical part, where, speaking of the natural yellow and black diseases, I shall show the differences between this and the black or brown corpse produced by the same principle as produces the calcified or muscardine corpse, which may be called the black muscardine disease or spurious mummy.

[6] Now that it is in the power of man to reproduce this cryptogamic plant, which is as wonderful as it is pernicious, now that it has ceased to be the exclusive prerogative of nature, its growth can, by artificial means, be made

so luxuriant that the stems and the way they grow can be clearly discerned with the naked eye, and by using a compound microscope, even one of the common sort, one can see the shape and the filaments, now straight and now curved, and often interlaced, which excludes the hypothesis of a crystallization, since we know that crystallizations give straight threads, not curved or interlacing ones.

The greatest efflorescence is obtained by placing the insect that has died of *calcino* in a damp place protected from the fresh air. The greater the dampness and the heat, and the stiller the air, then the thicker, the taller, and the more luxuriant the fungus grows. The warmth and the dampness, however, must not be excessive: too high a temperature kills the disease-bearing germ, and too much dampness sets up putrefaction, which kills the seed of the parasitic plant.

To obtain the greatest size, it is necessary to cut in half the corpse of a silk worm that has died of the mark disease, particularly that of a chrysalis, as soon as the humours begin to coagulate in it, and having covered it with a small vessel, e.g., a liqueur glass, to place it in a cellar or other damp place. Then use the mummies in which the deadly fungus has developed best, to inoculate other chrysalises, and treat them in the same way. Caterpillars of a different species from the silk worm, moreover, if they are killed when they are in the larval stage by using the same fungus and covered up, as above, without the body's being cut in half, sometimes show an efflorescence which is truly wonderful for its singular shape.

If this parasitic plant is observed with the great microscope of the illustrious De Amici, which magnifies the object more than thirty million times (sic), it will be possible to see all its minutest ramifications in it, and perhaps its reproductory organs as well.

If one wishes to observe the substance through the microscope in order to understand its organization clearly, one must place a small piece—about as big as the head of a small pin—of a chrysalis that has died of *calcino* and just become solid, between the two small circles of glass in which objects to be examined are put, and place the substance prepared in this way and still wet with its own moisture in a very damp place, so that it shall flower, in other words become covered with the parasitic plants.

[7] The muscardine fungus that enters the insect, develops in it and kills it, subsequently brings its fruits to maturity in the body of the victim, emerges or does not emerge on to the surface of the body, and, if it emerges, grows to a greater or lesser height above it, according to the hygrometric state of the surrounding atmosphere. If the air is damp, it does not decrease the internal moisture of the dead insect, and moreover it keeps its skin soft and tender so that the parasite draws greater nourishment from its victim, and meets with less resistance as it pierces its skin and grows out of it. But if the air surrounding the body is dry, it diminishes the internal liquid and makes the skin firmer, so that the deadly plants grow less vigorously in the dead worm, and have difficulty in finding a way for themselves through the hardened skin.

If one exposes a silk worm that has died of *calcino*, whether in the larva or the chrysalis stage, as soon as it is dead, to the wind or sun, or even merely to the open air, taking care to turn it frequently so that it dries on all sides, the dryness of the atmosphere that decreases the moisture of the dead worm is less favourable to the growth of the fungous plants inside,

and by making its* skin harder hinders them from issuing forth on to the surface of the corpse, which consequently does not turn white or become covered with efflorescence. The opposite result is obtained by putting the silk worm in a damp place or covering it up in some way or throwing it on to the bottom of a glass decanter, leaving the mouth open so that it does not putrefy.

If, however, the dead worm is cut in two, as above, particularly if it is in the chrysalis stage, when the body begins to acquire consistency and becomes solid, it turns white or becomes covered with efflorescence in a few hours on the two inside faces thus laid bare, especially if the temperature is very high and the body is placed in a damp place, or covered in some way, or put in a glass vessel, as I have mentioned. This only happens later and slowly if the dead animal is left whole, especially if it is in the chrysalis stage, for no other reason save the resistance that the outer skin offers to the parasitic fungi. Thus those species in which the hardness of the skin cannot be overcome by the growth of the parasitic fungi, do, it is true, when the insects have become calcified, contain the muscardine contagion in their internal parts, but none on the surface of their bodies which is free from fungi. I communicated the mark disease to two caterpillars of *cossus ligni perda* or Rodilegno: but as their hard skin did not allow the fungous plants inside to pierce it, they only emerged through the stigmata and under the belly of the dead insects, where the skin is thinner or had remained damp and soft from contact with the litter under it; and in the respiratory passages or stigmata, it did possess the power of causing the same disease in others. Over the whole of the dark part, i.e., the part that had not turned white, the contagion was absent. That part became contagious here and there, when, after the plants outside the body had become desiccated and I had moved the body several times, their seeds were able to scatter themselves a little over the surface of the body of the dead insect.

Similarly, in the silk worm that has died of the disease as a chrysalis, the little parasitic plants do not often succeed, in a dry atmosphere, in piercing the tough membrane that covers it, especially between the two annular segments, in the space between which the skin is thicker or at least harder. If it is touched there with a needle or otherwise, no contaminating spot is detected, although the more depressed parts nearby sometimes turn a little white—none, at least, until the fungi that have come out in those places with their seeds shut up in their various basins infect the rest of the surface of the corpse by pouring them out. Indeed, these chrysalises that have died of *calcino* turn entirely white only as the result of the expansion or branching of the little fungous plants at the annular divisions referred to, since the greatest firmness is found in the skin precisely at the mid points of these intervals, unless abundant moisture greatly softens even these hardest parts of the skin of the dead insect, as I was able to ascertain from my numerous experiments.

These principles being stated, it will easily be understood why the silk worm which dies of mark disease when it is shut up in the cocoon it has made, whether as a larva or as a chrysalis, should sometimes be found sticking to the silky tissue it has produced, and should sometimes be loose inside it. When the worm infected with muscardine shuts itself up inside

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* The original has "their." (Translator's note).

the cocoon and dies in the larva stage before changing into a chrysalis, the dead body adheres more easily to the wall of the tissue on which it rests, and, because it contains more moisture and has a thinner skin than when it has passed into the chrysalis stage, the deadly fungus grows with greater vigour, pierces the skin above, and plants its stems in the tissue, to which it clings and even beyond which it not infrequently grows. The chrysalis, which contains less liquid and is moreover covered with a cartilaginous membrane, is consequently less liable to produce this result. The damper the surrounding air, and the moister the dead insect, the more easily and completely the silk worm which dies of muscardine, whether as worm or as chrysalis, clings to its tissue, and the more it becomes covered with its white robe.

How immense and prodigious the reproduction of the vegetable parasite which causes the mark disease and all the other phenomena is, can be seen by cutting up a silk worm that has died of this disease, whether as grub or chrysalis, into thin round pieces, as soon as it has taken on the density of a soft paste, and by protecting these pieces from the fresh air by placing them under a glass or some other vessel. These portions of the body are soon completely covered with the cryptogamic plants in question, which grow as thickly as they do on the whole surface of the worm if it is not cut up, even though the surface has been so much enlarged. The more one increases the surface of the dead insect by cutting it up lengthwise or crosswise into thin discs, the more numerous the parasitic plants become, so that many millions of them are produced in one single insect. But the more the total number of the fungi is increased by greatly increasing or enlarging the surface of the corpse, the less nourishment they receive, and the less they grow and ramify; in exactly the same way as other vegetables, which grow less, the less food they derive from the ground on which they are living.

These and other observations clearly prove that the fungi with which the corpses of silk worms that have died of muscardine become covered, arise and develop in the dead body in which they came into existence from similar organisms that entered into the living worm, i.e., from seeds of identical fungi, and do not come, as some might think, from the seeds of cryptogamic plants or mould spread about in the surrounding air. Many experiments of mine have proved that a dead silk worm which is in some way preserved from corruption and which is almost as firm and solid even as a calcified worm, if it is placed in the same favourable circumstances in which a silk worm that has died of mark disease becomes covered with efflorescence, often turns white as the result of vegetation due to seeds coming from the surrounding air or already present in the body of the dead insect: but these moulds that belong to a completely different species of cryptogamic plants from that which causes the mark disease, although in appearance very like those which cause the terrible disease, vegetate and reproduce themselves only on the dead body and never on the living one, never communicate muscardine, and, even if inoculated into a worm, never kill it and do not even affect its health. The species, on the other hand, which causes muscardine, does not develop unless it enters a living insect, and its seeds only germinate inside the creature attacked, never on the surface of its body, and never, *never*, as has already been said, inside or on the dead substance. On it they preserve their latent life for a time, in the same way as they preserve it on various inorganic bodies, and on organic ones, too, when they are not actually putrefying.

[8] That there exists inside the calcified silk worm a substance similar to that which makes it white outside, is proved by the contagious power that the corpse preserves, even internally, since, if the whole of the upper crust of the insect covered with efflorescence is scraped off with a razor, the blade being taken over the dark part as well, and if the dead insect is then passed several times over a flame in order to remove from the outside any of the disease-bearing substance that may remain and afterwards cut lengthwise or crosswise in two, it is still found to preserve the contagious power even in its more central parts, whether it is used by contact or by inoculation. The experiment must not, however, be delayed many months after the death of the insect has taken place, since if one allows the corpse to grow too old, while the contagion remains active on the surface of the body of the dead silk worm, it is sometimes found to be already extinct inside it.

A substance like the efflorescence on the outside of the insect that has died of muscardine can be seen with the naked eye inside the chrysalises of Dispar moths, which, although hard and dark outside, are nevertheless seen to be calcified white inside if they are cut in half.

[9] That the muscardine germs reproduce or at least perfect themselves in the insect invaded after its death, is proved by many observed facts, particularly the following.

If a silk worm in the larva or chrysalis stage is inoculated with the moisture of another silk worm which has just died of muscardine disease, in both stages, i.e., whether it is a worm or a chrysalis, the injection usually turns out to be harmless, or sometimes produces the black disease, and rarely calcification; because in the first case the point of the needle has picked up no germ or only an immature one, in the second it has touched germs not yet properly fertilized, which give the black disease, like the very weak or degenerate ones that kill the insect they enter but do not calcify it, and in the third case only did the needle come in contact with fully developed germs capable of producing—as in fact they did—hardening and calcification.

If instead of using the moisture for inoculation, one bathes the whole body of a worm or a chrysalis with it, one nearly always obtains calcified corpses; because in this very large quantity of matter, there are germs already formed and fertilized, which is unlikely to occur in the very small quantity of liquid that is touched by the point of the inoculating needle if it is plunged into the corpse when the germs are being formed or perfected.

[10] In how many ways and with what and how many substances the muscardine germs can be killed or rendered harmless, we shall see in the second part of the present treatise.

[11] If some of the muscardine dust is placed in a glass vessel or something else, in a decanter for example; if the container is then shaken and a needle introduced into it without touching the sides; and if a silk worm or other caterpillar is then pricked with it, whether it is a larva or a chrysalis, the terrible muscardine is communicated to it, just as if the needle had been in contact with a calcified silk worm or other caterpillar. If the same operation is carried out after the vessel has then been allowed to stand without being touched, the insect that is pricked with the new needle, far from dying or being salified, does not sicken or even show the slightest sign of discomfort, because the dust, although very light, is nevertheless heavier than the atmosphere, and therefore when the air in the decanter becomes still,

it settles on the bottom of the vessel, and thus leaves the air free from contamination, and hence incapable of supplying the germ that produces the mark disease.

[12] If one sticks a steel needle into a silk worm killed by the mark disease or muscardine, whether it is a larva or a chrysalis, providing that it is still soft, in a few minutes the needle turns very rusty, whereas no rusting is caused by silk worms that are still alive, even though they are affected by the same disease, nor by others that have perished from some other cause than from the effects of the disease in question.

Only silk worms in the chrysalis stage, both alive and dead, can rust the needle, but only slightly, and not so quickly. In them, the rusting of the pin or whatever it is, must be caused by the bombic acid of the chrysalis itself and not by phosphoric acid. This acid is most evident in insects that have died of the mark disease after the death of the insect, usually as long as the corpse retains a certain degree of softness; but when subsequently the acid becomes united with other substances or forms compounds, it gradually, as the dead insect turns hard, ceases to give signs of its free presence to the needle.

It should be noted that not all silk worms that are killed by the muscardine germ turn the needle rusty. It is only turned rusty by those that contain the phosphoric acid necessary to salify them and preserve them from decomposition; and these are also the ones that possess the contagious power, since they are provided with the various germs or seeds reproduced or perfected. This fact leads one to suppose that the phosphoric acid is generated by the fructification or the fertilization of the seeds of the invading parasitic fungus, since those silk worms which die of black muscardine, and in which the muscardine germs did not reproduce themselves or at least were not fertilized, are not capable of turning the needle rusty, just as they are not able, either, to give other insects the disease by which they themselves were killed. But, occasionally, however, one finds some which, although black and corruptible and without the power of communicating muscardine, do nevertheless turn the needle rusty, almost like the true calcified worms: and I think that these are those in which the phosphoric acid is already formed and released, and the salification of the dead insect is then prevented for some reason, so that the acid, which is free, rusts the needle to a greater or lesser extent until the putrefaction of the corpse advances and decomposes it altogether; and this supposition is rendered even more probable by the observed fact that these corpses are firmer and decay much later than the other black ones.

That phosphoric acid is, if not the sole, at least the chief preservative of the silk worm or other caterpillar that has died of muscardine, can be seen by moistening a living worm several times with impure phosphoric acid obtained from bones, or combined with a little lime or a little magnesia; it soon dies and is preserved like the other insects that die of muscardine.

One can, moreover, easily ascertain what the acid substance which has been mentioned above really is, by analysing the rust taken from large numbers of needles stuck into silk worms that have died of the mark disease.

[13] It is worth knowing how to tell these two varieties from each other, since less powerful agents are required to kill the seeds of the first than those of the second. In order to tell whether the parasitic fungus, by which the silk worms which one can see dying are invaded, belongs to one variety

of muscardine or the other, one inoculates some chrysalises, and when, with a temperature of not less than 15°, they die in about three days and always before the end of the fourth after the inoculation, the deadly plant belongs to the more vigorous variety. If on the other hand the disease inoculated takes five and more days to kill them, and always more than four, at an even higher temperature, the germs of the parasite belong to the less active variety. It is necessary, however, when inoculating, to make use of germs not weakened by time or otherwise, or else even the seeds of the most powerful variety sometimes take up to eight and ten days to destroy the life of the insect into which they have been introduced: but if the insect is able to nourish them well, the new germs generated in it possess their former natural virulence, in other words the strength characteristic of the variety to which they belong. The most suitable germs for this kind of experiment are those from the current brood of silk worms: those of the previous years may do, too, if they have been well preserved.

[14] I have for many years possessed this variety which does not turn red. Being passed several times through several species of worms and being several times restored to the silk worm, it never underwent any modification or alteration of any sort.

I have never seen the blue one, but a friend of mine observed it amongst his worms that were attacked by muscardine, and I am sorry that he did not let me know in time for me to be able to obtain some of the worms that had turned this colour, so as to preserve a variety so uncommon amongst those of the parasitic fungus in question.

[15] From the many experiments which I undertook with the object of learning the duration of the muscardine contagion, I found that the deadly parasitic plants which keep their seeds longest alive, so that they almost complete the third year of their age, are those which grow most vigorously on corpses exposed while they are still fresh to the greatest degree of humidity that they can bear without putrefying and then preserved, when they have reached their maximum growth, in a dry place protected as far as possible from draughts, but not in closed vessels. In these circumstances, the fungous plants grow luxuriant like cotton-wool or down on the surface of the dead insect, and always remain flexible without ever becoming powdery, even though they are dry, and always keep their seeds locked or shut up in their receptacles.

If, however, these fungi, after becoming well formed and extremely vigorous with the help of very damp air, as I have said, are left for a considerable further period subject to this excessive humidity, clinging to the corpse of the insect in which they came into being and grew, putrefaction gradually sets in in the animal substance underneath, and the seeds of the deadly parasite, affected by this internal process, deteriorate and die; and, if they are then injected, they produce, not calcified, white and durable worms, but black, corruptible ones, such as are produced by calcified ones left to soak in water for many hours—with the single difference that the corpses resulting from this injection turn softer and have a much stronger stench than the latter.

Speaking generally of mummies covered with efflorescence or which have turned white, if the germs or muscardine seeds are enclosed in vessels while still attached to the dead insect, as it decays, even though slowly, it destroys the life of the germs; and even if they are detached from the body of the

dead insect in the fine dust mentioned, they die also if they are kept shut up too tightly or for too long. They need to be protected from frequent changes of air, but they do not live long if the renewal of the air is entirely or almost prevented; so that if the dust containing the seeds is kept shut up for a year and more in several boxes, one inside the other, the contagious material being placed in a small one and that in a bigger one and so on up to seven or eight or more, the disease-bearing germ soon dies, whereas if it is shut up in a single box it lives for a long time.

CHAPTER V

In what ways the deadly calcino or muscardine germ enters the silk worm establishment and the silk worms, and how it multiplies in them and then spreads all round in large numbers.

All bodies, organic and inorganic, alive or dead, including water and air, are carriers of muscardine, excepting only those that kill it immediately they touch it.

When muscardine appears in a building where silk worms are bred, it easily passes and spreads from one room to the next, and from the establishment of one owner to that of his neighbour, particularly if it becomes epidemic, and so on from house to house, until it infects a whole or nearly a whole district. Then it spreads and attacks another one, more or less distant, by virtue of the many different relationships, and exchanges between them, as well as the movement of the atmosphere itself, which carries the fatal disease-bearing dust on the wings of the wind, and by means also of several creatures—dogs, cats, rats and mice, and even flies. These last alight on insects that have died of the mark disease and that contain the muscardine seeds, or on other contaminated objects, pass on to other places, and there deposit the fatal germs clinging to them on the various things they touch, and sometimes even directly on the silk worms themselves.[1]

One of the ways in which the mark disease spreads and increases amongst a breeder's silk worms without his being aware of it, is by the contamination of food. In the breeding rooms the servants, by touching some of the calcified worms, especially if they are already covered with efflorescence, or other silk worms or objects that these have touched, soil their hands with a highly contagious and infinitely divisible substance; and if they spread it over the leaf that they pluck or cut up or merely give out to the silk worms, they condemn to death all the worms that eat this infected food-stuff or merely come in contact with one of the spots on the leaf that have been thus infected.

Those persons who, under the name of *bigattieri*, go hither and thither, offering their services as expert silk worm breeders and then breeding these useful insects in other places, often carry around the seeds of the deadly muscardine, preserving its germs in their clothing and in the

few implements that they bring with them, and sometimes also in the silk worm eggs that they distribute, particularly those who come from high, dry places, where the deadly muscardine is wont to hold sway more than elsewhere.

Silk spinners or rather silk winders, if they are themselves silk worm breeders, are more liable than other breeders to the risk of suffering losses from the terrible disease, especially if the place where the worms are bred, adjoins or stands near the silk-factory or building in which the silk is unwound from the cocoons, since nearly every year they acquire cocoons that contain calcified worms or that come from lots or from premises in which the mark disease has flourished, and which are therefore strewn on the outside with the disease-bearing germs, either because they have been in contact with calcified silk worms or with infected persons or things, or because the cocoons containing the larva or chrysalis that has calcified and is clinging to the silky tissue itself, often at least if not always, allow the white efflorescence or rather the stems or branches of the deadly parasitic fungus to emerge through it on to their external surface. These cocoons contaminate whatever they touch—containers, tables, people, and other objects,—and these people or things, subsequently coming in contact with the silk worms or with objects used for breeding them, communicate the principle that produces the dreadful disease to the insects, and with it for the most part death and the subsequent calcification.[2]

The eggs, too, can carry the disease and even become the most harmful carriers, since, if they are heavily contaminated, they may infect a large number of worms that have just emerged from them and thus make the contamination of people, furniture, and premises more extensive and more intensive, to the greater peril and detriment of the worms, born and unborn.[3]

The disease of muscardine not being hereditary or capable by its nature of being hereditary, the silk worm, so long as it is enclosed in the embryonic state in its egg, can never be affected by muscardine; but as soon as the little creatures are hatched, they touch the infected outer surface of the shell or membrane of the egg that contained them, become contaminated with the germs of the fungus, soon come in contact with their brothers living together in a confined space, and infect even those that were not infected before. Thus the muscardined insects become extremely numerous, and those which have died infect others at successive stages by scattering in profusion the germs they have reproduced. Older worms become infected and the contagious germs become even more numerous and widespread; so that the epidemic quickly reaches its maximum degree of ferocity and slaughter, and the whole establishment is rapidly transformed into a mere sepulchre.

This catastrophe deprives the breeder of the whole silk crop, and spreads the most extensive and intensive infection in the breeding rooms,

and over the walls, the ceiling, the floor, and all the objects contained therein; and this inflicts the same unhappy fate on the worms of succeeding generations, unless chance or human skill prevents it or reduces it to a large extent. The poor creatures are stricken with the mark disease as soon as they are born because of the infection of the seed, and even if the first to be infected are few in number, they have time, by reproducing the fatal germs in them, to infect others, and these still others, and those newly invaded to infect still others, before they shut themselves in their cocoons, so that the deadly seeds of the fatal fungus, becoming gradually more numerous, may in this way kill all or nearly all the poor creatures, as in fact happens in such cases. But thanks be given to fate which has shown us an infallible means of easily avoiding such destruction.[4]

FOOTNOTES

[1] Flies can carry many kinds of contagion, if not all; but chiefly the muscardine contagion which clings even to the most polished objects, and which, being by nature volatile and infinitely divisible and multipliable can easily be picked up by flies from any object on which they may alight in a silk worm establishment infected with muscardine.

[2] The silk that is taken from the cocoons is also sometimes a carrier of the muscardine contagion, not because it still contains the pestiferous germs with which the cocoons that supplied it may have been sprinkled, since these having been placed in hot water in order to be unwound, the contagion has been killed; but because of the germs with which it may have been strewn when it was subsequently made into bundles, because of the contamination of the rooms or the cupboards in which these are placed, or from contact with some object infected with muscardine seeds.

To my knowledge, nearly all the silk worms produced by a hundred ounces* of eggs, were infected with the mark disease and killed, after they had undergone the first moult—all because the eggs had been left for many days in open vessels in a cupboard where there was much raw silk bearing muscardine germs.

[3] Silk worms' eggs can be contaminated on the outside in several ways, viz., by moths infected by contact with cocoons or tables or other objects strewn with muscardine germs; or by the infected cloths on which the moths lay their eggs; or by the movement of the air in a room thickly impregnated with muscardine germs, which carries them on to the eggs lying there; or by infection of the paper, the vessels or other implements that may have touched them; or in any other way in which the seeds of the deadly parasite may be carried on to them, from the time when they are deposited until the time when they hatch.

[4] After a large number of experiments performed with the object of finding a means of disinfecting contaminated eggs without injuring the enclosed embryo at all, I at last discovered one that is as harmless and cheap as it is simple and rapid.

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* *once*. The *oncia* is a measure equivalent to between 26 and 30 grammes, according to the district. (Translator's note.)

CHAPTER VI

Causes or circumstances that increase or diminish the virulence or the duration of the muscardine contagion or germ; that facilitate in a greater or a lesser degree its entry into the silk worm and other insects; that favour or hinder its development, its growth, and its reproduction therein, and then its diffusion or dissemination on the various bodies around and in the surrounding air.

The younger, in other words the nearer its birth or rather its maturity and fertilization, the muscardine germ, the more virulent it is: and the more protected it is from the movement of the air, and particularly from the fresh air, the longer it remains alive, and vice versa. Humidity, if excessive, weakens and then kills the germ, so long as it adheres to the worm, since the corpse, as it slowly putrefies because of the extreme dampness, gradually deteriorates and decomposes the muscardine germ. But if the germ has left the dead insect and is sticking to the ceiling, walls, or floor of the room, to the trays, the paper, or other objects, which are not corruptible or not actually putrefying, and which do not by their nature kill the muscardine germ, it suffers little from humidity, however great, providing the action does not last for very long. It preserves its latent life for many days, even submerged in water, and for some months longer if it is left to float on the surface.

The higher the temperature, at least up to about 32° R., the more easily the muscardine germ enters the silk worm; because the higher the temperature, the more it stimulates its vital power, and the greater the aperture and the activity of the absorbing vessels of the insect. The higher the temperature, too, the more rapid the development and growth of the parasite within the insect, the shorter the period of the disease, and the earlier death ensues. Low temperatures produce opposite effects, so that it takes up to twenty days and more to kill chrysalises inoculated with muscardine, and even longer to turn them hard and salify them, which occurs at six or seven degrees above zero, because the chrysalis does not live at lower temperatures and so the deadly parasitic plant cannot vegetate in it. And the more stagnant the air surrounding the worm, the more active the contagious germ on its body remains and the more easily it enters it, since it is not displaced from the spot it occupies on the silk worm.[1]

Firm dry food, dry air, health, and vigour increase the ability of the silk worm to nourish and to reproduce the muscardine contagion, by increasing or improving its food.[2] The ability of the worm decreases as the aqueous principle in it increases, because this reduces and deteriorates the substance that nourishes the deadly parasite, changing its proportions, whether the increase comes from very moist leaf, from a too damp atmosphere, or from some other cause.

If sickness or any other cause destroys, reduces, or deteriorates the food of the parasite in the insect, or if a weakness or defect in the parasite

allows it to make little or no use even of suitable food present in large quantities, the muscardine germ is harmless to the insect attacked. Sometimes under such circumstances it develops and achieves some growth, and so the deadly parasite, which vegetates but does not reproduce itself, kills the victim, whose corpse, however, does not possess the power of producing the mark disease in others, since it contains no organisms similar to those that infected and killed it.

Thus, other things being equal, youth constitutes the greatest virulence of the muscardine contagion, and old age its weakness, as with all organic creatures. The fewer draughts in the air surrounding the germ, the longer it lives and preserves its energy. Heat and stagnant air facilitate its entry into the silk worm and increase its effectiveness. Cold and ventilation have the opposite effect.[3] Good food, i.e., a more nutritive leaf, a dry atmosphere, perfect health, and vigour make the insect more fitted to nourish the muscardine fungus.[4] The opposite effect is produced by bad food, especially a watery leaf, a high degree of dampness in the atmosphere, a sickly or debilitated condition in the silk worm. The debilitation of the contagious germ, too, however it comes about, or any other defect inherent in it, hinders its development, its growth, and its reproduction, even though the food offered it by its victim is excellent and plentiful.[5]

The greater the combination of causes or circumstances that favour the genesis of the mark disease and the subsequent calcification and efflorescence, and the greater the number of silk worms that die of the disease and then turn white[6]—then the greater the number of the muscardine germs on the mass of worms that have died and turned white. The drier and more agitated the surrounding air, the more quickly these dry and spread around; and, as they spread on to all the objects nearby, the infection, the disease, death, calcification, and efflorescence increase steadily, and, this last killing other silk worms, the epidemic soon reaches the highest degree of fury.[7]

On the contrary, given equal muscardine infection, the fewer the causes or circumstances that favour the disease, and the greater and the more numerous those that oppose the production of the disease and particularly the subsequent calcification of the dead insect—then the smaller the number of new germs reproduced; and the damper and less disturbed the air inside the room, the less quickly they become dry and light, and leave the corpse. Thus the disease-bearing germs being few and not being widely scattered over the surrounding objects, they do not spread the infection and similarly they do not cause the number of sick or dead insects to increase much, and few of the remaining dead subsequently effloresce; for which reasons the disease seldom or never then becomes epidemic, and if it does become so because of the large quantity of muscardine seeds brought in with eggs, trays, or other infected objects, the epidemic is mild, and ends quickly.[8]

FOOTNOTES

[1] If the air that is in direct contact with the worm is changed frequently, and particularly if it is changed rapidly, then the seed of the deadly fungus not only decreases in vigour—and the more so the more rapidly the strata of air around it are changed—but also, being scarcely able, against the current of air, to remain on the body of the silk worm at the spot where it is situated, being carried hither and thither to other spots by the movement of the air, and sometimes even away from the silk worm altogether, has not usually enough time to enter the silk worm, either by being absorbed by the respiratory vessels or by penetrating the skin, to increase and spread subsequently through the lymph or blood system.

[2] The leaf in high dry places, the dryness of the air in the silk worm establishment, and the health and vigour of the silk worm, by keeping down the proportion of aqueous substance in it and increasing instead that of the other substances, chiefly of the acids and their main constituent principles, make the insect better able to nourish and reproduce the deadly parasite.

This ability is increased on the same principle by the practice of hatching out the worms by artificial heat, whereby the air in the little room becomes too dry. This easily happens if the air is heated by a stove, so that the silk worm loses a portion of its natural aqueous humour.

[3] One often observes that amongst several adjoining breeding rooms, in all of which the fierce muscardine is present and in which conditions seem to be absolutely alike, the disease rages much more in one than in another, and not merely in one year, but not uncommonly for several successive years. That is due less to the greater quantity of pestiferous germs present in this room from the preceding brood, which cover one another up so that those underneath are better protected against agents hostile to them, than to the inferior ventilation, the higher temperature, and the lower degree of humidity of the room. This absence of draught, greater heat, and greater dryness, while it increases the ability of the worm to develop and reproduce the contagious germs, makes the germs more vigorous, active for a longer time, and better able to introduce themselves into the silk worm and to infect, kill, and subsequently calcify a larger number of insects. Thus the quantity of disease-bearing seeds increases greatly, and the mark disease, both in the present brood and in future ones, must dispatch a larger number of the poor insects than in the neighbouring or adjoining rooms, even though in other respects conditions are perfectly alike.

The greater the number of muscardine germs brought into or developed in a breeding room and spread around, and the less ventilated, the warmer and the damper it is, then the more easily and frequently it is invaded by the parasite, and the better fitted the insect invaded is for nourishing and reproducing the invader.

[4] The silk worms affected by muscardine, generally speaking, are always the best in appearance and those which most flatter the hopes of the breeder, and they cannot but be such, because the most vigorous silk worms are the most easily attacked by the deadly disease, since they offer more or better nourishment to the cruel parasite, and because, generally speaking, the silk worm invaded by it develops better since it eats more, especially in the early stages of the disease, and it is only in the last stage of it that the diseased insect shows signs of suffering—i.e., when the deadly fungus having seriously de-

ranged its vital economy by its continual growth, is driving the poor victim to its end. When the worm is invaded by the vegetable parasite that feeds and grows in it, it must require more food, and therefore present a better appearance, until its organism deteriorates and the insect invaded, completely disorganized, falls an unhappy victim to the invader.

According to several observations of mine, the death of the victim seems to be the result of the stoppage of the circulation of the blood or lymph, whichever one cares to call it, caused by the excessive distension in the lymph or blood vessels of the tiny parasitic plants, due to the development and subsequent progress of their growth.

The greater the virulence of the contagion, and particularly the greater the ability of the insect attacked to feed it, then the greater the volume of the corpse, when it is quite dry, and the greater its hardness, other things being equal; because the more vigorous the fatal parasite is when it enters the insect, and the better and the more abundant the nourishment it finds there, the greater the quantity of animal substance that it converts into its own substance; so that the dead insect remains firmer and larger. Hence the greater hardness and the greater volume of a calcified worm compared with another similar one in the same circumstances, tells us that the first was better able to feed the contagion, or that the vigour of the invading germ was greater, or both at the same time.

These corpses therefore yield more contagious germs, providing the little fungous plants are not without the dampness and the softness of skin necessary for them to reach the surface of the body of the dead insect, and there to mature their seeds.

[5] Although the muscardine fungus develops, vegetates, and reproduces itself at all seasons from 7-30°R., indeed as long as the insect is alive, whether it is in the grub, chrysalis, or moth stage, in a longer or shorter space of time, according to the temperature, nevertheless its growth is more lively and vigorous in the months of May and June in the first brood of silk worms than in other months and in the later broods, other things being equal. That, I believe, is because all plants have periods in which they vegetate better than in others, and so it must be with the muscardine fungus, and also because the silk worms of broods after the first are usually, for several reasons, weak or at least less vigorous than the first.

All healthy silk worms moreover are capable of feeding the fatal parasitic fungus to some extent and consequently of becoming infected with the mark disease if they are invaded by it; but not all, when they are dead, turn equally hard and become equally covered with the familiar efflorescence in the same circumstances, and many, when they are dead, turn black instead of becoming calcified, because not all silk worms can provide the invading plant with equally rich or equally suitable food. Generally speaking, these last are those that contain an excessive proportion of aqueous substance. Thus not all muscardine germs, though they are all alive or endowed with latent life, are capable, on entering insects equally fitted to nourish them, of producing the same effects, i.e., calcification, or equal hardening and efflorescence, although, being alive and active, all are capable of killing the insect that contains them. Seeds or germs much weakened by extreme age or by long exposure to fresh air or by long immersion in water, or by some other cause, generally produce corpses that are black or only slightly calcified.

In order to study the nature and habits of this parasitic cryptogamous plant, it is necessary, in the respective experiments, to use chrysalises taken from the cocoons more frequently than silk worms in the grub stage, and to use inoculation; because, with simple contact, in view of the lack of porosity of the membrane covering the chrysalis, the disease-bearing seeds cannot easily enter it, and it is hard to cause a chrysalis to perish and calcify by contact alone, even if one makes it touch along the whole of its length another that has already turned white. The silk worm that has reached the chrysalis stage, because it takes no more food, because it does not absorb the humidity of the atmosphere so much, because it contains less of the aqueous principle, and finally because it does not move from the place in which it settles, is more fitted to develop, nourish, and reproduce the deadly parasite once its seed has entered it: and therefore the effects of the growth of the fatal fungus are clearer, readier, more regular and more constant in chrysalises: so that one can observe the nature and habits of this parasite far better in them than in young worms.

[6] One of the main causes, for example, which may favour the production and propagation of the disease, is the course of a warm and dry season, which while making the seed of the parasitic fungus lighter and more volatile, i.e., more diffusible in the surrounding air, and increasing its vigour, at the same time makes the atmosphere dry and the leaf of the mulberry less moist. The first circumstance makes the muscardine attacks more numerous, since the contagion approaches the worm more frequently, and renders its entry into it and its development easier and more rapid: and the second, i.e., the dry air, and the less juicy food, by diminishing the proportion of aqueous substance in the silk worm, increases or improves the food of the voracious parasite, so that the quantity of insects that are infected and that die of muscardine increases; and amongst them, also as the result of the same conditions, the number of calcified, efflorescent insects increases more than usual. The damp vapour surrounding the insect that has just died of muscardine (it is never absent in the silk worm that dies in the larva stage, because of the separation of the aqueous principle during the salification and solidification of the corpse by the phosphoric acid)— this aqueous vapour favoured by the greater heat of the season promotes the efflorescence on the body of the dead insect; and the more quickly and the more thoroughly the surrounding air then dries, the more rapidly the efflorescence becomes dry and spreads the deadly seeds about.

[7] The more active the muscardine germs present are because of their age, their nature, and prevailing circumstances, and the warmer, the drier, the calmer, or the less disturbed the surrounding air is, the more abundant the silk worms in the breeding room are and the closer together on the trays, and the healthier and the more robust they are, and the smaller the proportion of aqueous principle they contain so that the victim offers more abundant and better nourishment to the parasite and the latter is more capable of taking advantage of it — then the number of insects that fall sick, die and calcify, increases, and with them the seeds of the cruel parasite; and the more numerous these become, the more silk worms they infect and cause to sicken and die, so that mortality would become general if the terrible scene did not come to an end when the healthy silk worms shut themselves up in their cocoons, where they are sheltered from the further attacks of the formidable enemy.

[8]Everything that increases the dampness of the atmosphere reduces the vigour of the muscardine germ or seed: and everything that increases the aqueous principle in the silk worm diminishes the vegetating power of the deadly fungus that has entered it.

The damper the air of the place and the breeding room, the more vigour the muscardine germs lose, especially with the lapse of time between one brood and another, and the more slowly and the less thickly they spread over the surrounding objects: the damper the air and the moister or the wetter the leaf, the less able the silk worm is to nourish and reproduce the invading vegetable parasite.

Where the atmosphere is very damp and the food of the silk worm very watery for some reason, the muscardine germs which, when they enter the silk worm, are weak or less virulent than they would otherwise be and which find insufficient or unsuitable food in it, do not always reproduce themselves, and when they do they produce weak offspring or fruits, and these even weaker successors, which are even less capable of procreation, so that normally, when they enter the insect, they do, it is true, kill it by developing, but since they do not reproduce themselves, the corpse of the victim, which turns black, is not capable of giving muscardine to other insects.

Besides the fact, therefore, that the silk worms that have died and turned white are less plentiful, even the mummies which have become covered with efflorescence, as the result of the great humidity of the air, retain the muscardine seeds longer in themselves; and the heavier this humidity makes them, and the more attached to the objects on which they are, the less easily they rise into the air and spread about.

The germs or seeds, moreover, of which we are speaking, being already weak for the reasons given, or from the weakness of their predecessors, and becoming more and more debilitated in successive reproductions, grow feebler and feebler when the breeding of the silk worms is finished, since they are unable to procreate or renew themselves until the following year, and since, between one brood of silk worms and another they meanwhile remain for a long time in a damp atmosphere. Thus, at the time of the new brood, they are either dead or so weak that, even if they do enter the silk worm they cannot easily reproduce themselves in it; and, as they do not reproduce themselves but merely develop, the insect invaded, when it dies, turns black and its corpse is therefore unable, as I said before, to communicate the mark disease to others, being without muscardine seeds, or at least without perfect seeds; and in this way the terrible disease ceases.

That is why, in countries that are well-watered or otherwise damp, the disease never or rarely does great damage, and diminishes or disappears the following year, and much more in subsequent ones; and that is why, in high and dry ones, on the other hand, it so often wreaks great havoc amongst silk worms to the great detriment of their breeders. The better food and the dry air make the silk worms even more robust, and the latter, i.e., the dry air, dries the fatal dust on the calcified worms more completely and more rapidly, and spreads it around more quickly and more plentifully, so that the holocausts are more violent and more frequent, and last longer, and the disease ordinarily increases more and more in the subsequent broods, until accident, in the absence of technical skill, diminishes or even wipes it out altogether. A damp, cold, and rainy spring, and better two such, one after the other: better ventilation in the breeding rooms, because of new

apertures or because those which have already been there for a long time have been kept less closed, especially between one brood of silk worms and the other, or because, during the year, there have been strong gales blowing in the right directions to displace and gradually renew entirely the air inside the breeding-establishment: its atmosphere having been made very damp for a long time by the fermenting litter or some other cause: much more watery food than usual being given to the silk worms, and for several days, with leaf soaked by rain or dew, or extremely moist from some other cause: a change of rooms or of breeding equipment replacing infected premises and implements by uncontaminated or less infected ones: breeding interrupted or suspended in the rooms for over a year,—these and other accidents, especially if several occur together, may very well slow down the progress of the disease and sometimes even arrest it entirely.

CHAPTER VII

The muscardine contagion multiplies much more, and wreaks greater havoc amongst the useful insects than other kinds of contagion that afflict animals whose life is much longer or lasts for several years.

Considered as organic beings, the contagions that afflict animals—leaving aside those that attack plants — obey, in their growth and in their spread, the same laws as govern all living beings in general, which increase and multiply in proportion to the food they receive.[1]

When a contagion is carried into a district where it has never raged, or where it has not raged for a very long time, if the atmospheric constitution of the place is favourable and if it finds the creatures destined by nature to reproduce it capable of providing it with suitable and abundant food, it passes from one subject to another, from one family to another, from one district to another; and thus, as the disease-bearing seeds increase as the number of diseased creatures increases, the disease quickly becomes epidemic, rages fiercely, and brings suffering and often tremendous destruction amongst those unfortunates who have been so unhappy as to be stricken by it; and, exhibiting its maximum fury in this way, it does not diminish until the number of victims to be destroyed or of beings to be tormented decreases.[2] At last, when the pestiferous germs find no more creatures in which they can feed and reproduce themselves because they have invaded and consumed them all except those that are immune by nature and those that have by accident or design eluded their contact or that although touched, have not been invaded or penetrated by them, the contagious disease which has already diminished goes on diminishing until at last it stops entirely.

Meanwhile, as the seeds of the contagion in general do not increase any further because they can no longer reproduce themselves, suitable subjects being lacking, they grow gradually weaker as they grow older and finally, with the lapse of time, die, by a natural law, as organic beings, either from the movement of the air, their eternal enemy, or by means of other destructive agents, brought by accident or by design.

But nature, being anxious to preserve her productions, transports some of these germs, by various means, to other places, more or less distant and sometimes very distant. If they are still alive when they arrive there and remain so and find suitable and abundant nourishment in the creatures they invade, they re-enact the dreadful scene amongst the inhabitants of their new home, exhibiting their natural ferocity in its entirety: and the better the food that the victims offer for their reproduction, the greater the havoc they wreak amongst those unfortunates; and the longer the victims have been previously left in peace by their enemies, the more food they now offer them; and that food is usually even more plentiful—indeed, extremely abundant—when they have never in the past suffered from the contagion.

But if, on leaving their native district to be transferred elsewhere, they perish on the way, or if, on arriving in another district, they are there destroyed by a different atmospheric state, or by conditions peculiar to the place, or if, although still viable, they do not find in the creatures they attack suitable material for their development and growth—in all these cases, their presence is harmless. And if, although alive and vigorous, they do not find food suitable or sufficient for their reproduction, in the creatures into which they introduce themselves because of their previous invasions or for other reasons; or if they are weakened on their journey or during their stay or rendered otherwise defective for any reason, so that they are unable to reproduce themselves or to produce perfect germs, although they are nevertheless able to develop and to feed in their victims: then they do, it is true, produce the same disease in them, but it is sporadic and never contagious, since the diseased creature lacks new or at least fertile germs able to cause the disease in others.

But if, amongst beings generally unable to reproduce the contagion from some defect or because of a dearth of the substance that feeds it, there are some which can nevertheless render the germ fit for that function, the disease is then contagious: but the new disease-bearing germs, not finding other creatures capable of producing them, or very few, amongst those that they invade, are soon finished, and the contagion, although by nature one of the easiest to communicate and extremely quick to spread, never produces serious consequences, and the cruel disease can never in this case become epidemic.

But it is very different when, amongst the germs that are extremely weak or degenerate and therefore unable to reproduce themselves even when they find creatures that can provide them with all the necessary food, there are some that are not enervated or defective, or that, although weak or somewhat defective, are nevertheless helped by the most favourable circumstances, and therefore succeed in generating and producing fertile seeds. The inhabitants of the place being endowed with the greatest, or at last with great, ability to nourish and reproduce the contagion, the new pestiferous germs multiply rapidly in infinite numbers and, spreading all around, very soon present the terrible spectacle of a contagious epidemic.

In this way the germs of the various animal and vegetable contagions travel about, being transported hither and thither by so many bodies, dead and alive, organic and inorganic, and on the wings of the wind—especially the lightest germs and those that can live without a liquid or an animal mucus to envelop and preserve them. And while they are waiting for chance to carry them on to animals that are alive and suitable to reproduce them, the destructive agents, which are brought to them by accident, by design, and above all by the movement of the fresh air (their eternal enemy), gradually destroy them; and the passage of time performs the same operation more or less quickly according to their nature, because, as organic beings, their life must sooner or later come to an end.

These are the effects produced in general by the contagions that afflict man and other animals, and that live for a long time, or at least over a year; but even greater evils are produced by those, such as *calcino* or muscardine, peculiar to the silk worm and other caterpillars, which attack short-lived creatures.

The former often attack creatures that have previously been attacked by the same species of contagion, and whose supply of the substance feeding the parasite has been exhausted or impoverished, so that the organism contained causes no harm to the creature containing it or generates in it only a sporadic malady, since it does not reproduce itself for lack of food.

The latter, particularly the muscardine germ, which always invades insects as yet untouched by its greed because they are new born and because their brothers and sisters that had previously been invaded and consumed have already been killed,—this cruel parasite wreaks much greater havoc among the precious insects—havoc all the greater since the disease-bearing germs and the insects capable of nourishing and multiplying them are greater or more numerous in comparison with the contagious germs peculiar to the human race and other long-lived animals and with the respective individuals capable of being attacked and infected by them[3].

Fortunately, not all silk worms are able to reproduce the contagion, even though they are capable of feeding it[4], and if the insect does not reproduce the germs that have attacked it, it is not capable, when it dies, of communicating the malady to others, and its corpse, which has therefore turned black, opens the tomb for the deadly invading parasite, doomed to perish without being able to procreate or produce perfect organisms similar to itself[5].

FOOTNOTES

[1] Perhaps some of my readers will smile at these ideas of mine, seeing me revive the theory of living disease, which has already been so often discussed, and which is being more strongly combated than ever before, although one of its stoutest supporters, the celebrated Professor Rasori, is still alive. But after so many observations and experiments I have carried out to find the cause of the mark disease or *calcinaccio*, I should consider myself to be going counter to reason if I did not hold that this contagious

disease is produced and spread by a being endowed with organization and life.

Sometimes the epidemic may diminish and terminate even then, and rapidly, especially if some extraordinary change in the atmospheric state weakens the disease-bearing germs considerably, or destroys them, or renders the insects attacked less able to reproduce them; as may happen with the change from great dryness to extreme dampness in the air, particularly if it is sudden, or from great heat to cold, and vice versa, or from the maximum degree of positive atmospheric electricity to negative.

But such an occurrence must be much rarer than is commonly believed. Usually, if not almost always, the epidemic wanes and comes to an end for the opposite causes to those which produced it and made it wax. The natural increase of the contagious germs constitutes the epidemic and brings it to a greater or lesser degree of intensity, according to the greater or lesser number of the pestiferous germs and their greater or lesser virulence; and their decrease and their subsequent debilitation then causes it to decline and brings it to an end.

As the reproduction of the attackers diminishes with the diminution of the attackable beings, the disease-bearing germs become rarer and older, and therefore less vigorous. Moreover the latest and the last victims being normally the least suitable to nourish and produce the contagion, the pestilential germs which, when they enter them, are already somewhat weakened and are ill nourished by them, cannot but produce progeny that are even more languid than their parents, and these are succeeded by an even more languid generation. For these reasons, the contagion loses strength daily until it finally ceases to rage and disappears, to reappear in an equally cruel, and sometimes in an even more terrible, form in other regions as yet untouched by its rapacious cupidity or ravaged by it long since.

[3] The muscardine contagion can wreak far greater havoc among silk worms bred in establishments than a contagion brought from afar into a region or district where it has never previously been known and whose inhabitants are all or almost all capable of reproducing the cruel parasite can wreak among man or the domestic animals which serve him, because the contagious germs that are brought from afar are normally few in number, or not very numerous, and moreover they cannot easily preserve their original vigour in their long journey; whereas, if the mark disease has raged as an epidemic in a silk worm breeding-room the year before, and neither accident nor human intervention have greatly diminished the number of deadly germs or weakened them, the muscardine germs present in it are extremely numerous and virulent; and the insects capable of reproducing them are very numerous too; and the two are always in close contact.

And even if the contagious seeds, when they have been reproduced, pass from one district to a neighbouring one and the contagious disease rages as an epidemic, there is no closed place in which one can find so many invading and invaded creatures assembled as in a silk worm breeding establishment that is being badly devastated by the fierce muscardine; nor does any other species of contagion spread, I think, so easily as muscardine.

It is said that the contagion does not act in proportion to quantity, since the disease is not aggravated by introducing a greater quantity of the disease-bearing substance into the victim. But it is certain nevertheless that a greater quantity of the contagious substance placed in contact with a

creature capable of being infected by it, always exposes it to a greater danger of contracting the disease, which might not have started, perhaps, if the quantity of contagious substance that touched the victim had been slight, as I am about to show.

The muscardine contagion, like other contagions, does not act in proportion to quantity, since the disease is not aggravated nor death accelerated although the disease-bearing substance is introduced in large quantities into the insect and it is repeatedly touched and inoculated with it. But the greater the number of muscardine germs that come into contact with the silk worm, the more easily the invasion of the enemy and hence the death of the invaded insect occur. When the seeds of the parasitic plant that have access to, or that touch, the worm are very, or rather extremely, numerous (even though they are nearly all either for the most part immature or weakened or badly situated), some of them less defective or more fortunate than the others manage nevertheless to enter the insect somehow (by means of its inhaling or respiratory passages or with its food) and to develop and reproduce themselves in it.

If one touches a calcified worm known to be contagious [several times]* with the point of a very fine needle, and if one touches a living and healthy silk worm with it each time, touching each on a different place or spot, of the many silk worms touched in this way some will continue to remain healthy, not so much because no active germs have been deposited on them, as because they were unsuitably situated and unable to enter them†, or because they have been detached in some way, or from some other cause. When, on the other hand, one squeezes the calcified worm between two fingers and rubs a silk worm with them, doing the same thing with other silk worms, even though there is a large number of them, not one will escape death.

Thus if one pricks several silk worms that have just died of muscardine with an equal number of needles and inoculates healthy silk worms with them, some of these will not be affected, others will die but not be calcified or salified, and others will turn hard and be salified, the reason being that the muscardine seeds, i.e., the seeds of the parasitic fungus, do not form, or at least do not mature, until after the death of the victim. Therefore when the silk worm has only just died of the mark disease and does not yet contain muscardine seeds or fertile seeds or contains only a few mature seeds (i.e., the first to be fertilized), the needle cannot extract any seeds, because there are none, or does not succeed in extracting any because they are very few in number, and in both cases the wounds it inflicts must be harmless. And if the needle takes with it seeds that are immature or imperfect or as yet unable to reproduce themselves, though capable of developing and feeding, the inoculation does kill the wounded insect, because the germs introduced into it, though unable to reproduce themselves, are nevertheless capable of developing and feeding, as happens with various plant-seeds which germinate and vegetate but are incapable of fructifying. But if the dead insect is pricked or cut in two and the liquid inside it is taken from it and the body of a silk worm in the larva or chrysalis stage is moistened all over with it, the death and the subsequent calcification of the insect

*The words in the square brackets seem to be required by the sense and have been added by the translator. (Translator's note).

†"it" in the original. (Translator's note.)

contaminated nearly always occur, because in such a quantity of substance taken from the dead insect, it is unlikely that there will not be some germs already mature and perfect.

Who can assure us moreover, à propos not only of the muscardine contagion but of all contagions in general, that one contagious germ is enough to cause the disease and even death in the creature invaded? Since the disease-bearing substance is infinitely divisible and the germs are so minute that on the point alone of a small needle there may perhaps be, not a hundred or a thousand, but perhaps a million, and still invisible to the naked eye, it may perhaps be that the disease, and still more death, cannot occur in the creature invaded unless so many disease-bearing germs enter it as suffice to bring it about. Who knows whether one or more germs are insufficient to carry such disorder into the vital economy, and whether they therefore turn out to do little or no harm to the creature that contains them, although it is capable of suffering from the same contagion, should it be invaded by a greater number of contagious germs? At least we cannot be sure of the contrary. And if we reflect that in the various pestilences, those who are exposed to contact with a greater quantity of the disease-bearing substance or to more frequent contact are the favourite victims of the prevalent contagion, particularly if they are in both circumstances at one and the same time, it seems that we must believe that not only are they more easily caught or invaded by the pestiferous substance, but they must also receive it in greater quantities than others who, being in different circumstances, are caught or rather entered by only one or a few contagious germs and perhaps remain unharmed, or do not fall ill at least until as many disease-bearing germs have on one or several occasions entered their bodies as are necessary to make them ill, and they, too, fall victims to the cruel disease. This reflection seems to make the conjecture given above extremely probable.

[4] There is no healthy silk worm that cannot fall sick of the mark disease if the seed of the muscardine fungus is inoculated into it, because there is no silk worm in a state of health that does not contain a greater or lesser quantity of the substance that feeds the fatal parasite, as I have already said elsewhere. If the insect inoculated does not die, it is because the germ which was introduced was inactive, or because it was not introduced into the blood system; for if one goes on inoculating, it finally perishes and turns black or calcifies and effloresces, according to the circumstances in which the attacker and the victim are.

[5] Contagions are in my opinion vegetable and animal parasitic beings whose germs, entering one of the creatures intended by nature for the preservation of their species, when they are perfect or able to reproduce themselves, and finding nourishment suitable for their reproduction there, fulfil their functions in this creature; and the new beings generated can, by entering other creatures, produce the same effects in them as their parents produced earlier. But if, because of some lack of food in the victim or some imperfection in the invader which renders it incapable of taking advantage of it, or for some other reason, procreation does not take place, as may occur when the victim dies before the invader can complete its reproductive functions, then the malady is sporadic since the newly procreated germs which enter other creatures and produce the same disease by exercising the same functions are lacking.

The victim subsequently succumbs to the disease if the cruel parasite, by

growing and procreating, or merely by growing without reproducing itself, vanquishes the opposing life force; and it gets better—disregarding human intervention—when the invader does not fulfil its functions, because of its own nature or from any cause that interrupted them before they could carry mortal disorder into the animal economy.

I observed a truly curious fact when I inoculated several Dispar moths in the larva stage with muscardine. Soon after the injection, these grubs, which were already mature, turned into chrysalises. From seven of these chrysalises a little cinnamon-coloured worm then issued forth, and in a few hours these seven worms also turned into chrysalises.

Such worms come from a species of fly that bores a hole in the skin of these insects, i.e., of the Dispar moth in the caterpillar stage, and lays one or more eggs in it, but usually only one in each insect. The egg hatches out, and the worm that comes out feeds on the insect in which it has been put, and when it is mature makes a hole in the skin of the insect inside which it is, in order to come out and turn into a chrysalis outside.

From four of the chrysalises of these little worms, there came out the same number of little flies. But what was my surprise when the other three little worms turned into mummies like the moths that had contained and fed them; so that both the invaded and the invader fell a prey to *calcinaccio* or muscardine, and the two insects, the container and the contained, were vanquished and slain by the strength of the plant. All the chrysalises of the moths which had been inoculated as above were cut in half when they had turned hard after their death, and they were all seen to have been turned white or efflorescent inside by the fatal fungus which had killed them; but while those from which no worm had come were all full and had no cavities, the others which had given food and shelter to the little insect in the larva stage were empty in the middle with thick calcification around. None of them, however, showed any efflorescence on the surface of their bodies, because the little muscardine plants were unable to overcome the stout resistance of the hard membranous envelope which covers the chrysalis of the moth in question.

Two species of parasites destined by nature to develop and feed in the grubs or moths in question, very different from each other, one animal and the other vegetable, thus entered the insects I have mentioned in the larva stage. The animal parasite, the first invader, in order to grow, fed on the more internal or central part of the victim, while the second that entered it, i.e., the vegetable or muscardine one, converted the less central part, i.e., that which is nearest the surface, into its own substance, according perhaps to the situation in which each invading being happened to be. But when the life of the invaded insect, i.e., of the moth, was extinguished by the muscardine fungus introduced into it, or perhaps also by both the parasites, animal and vegetable, the latter soon produced its fruits or seeds or at least perfected them in the corpse of the dead insect, and they were able to invade the other living parasite present in the dead insect, which therefore became infected with the mark disease and subsequently perished in the chrysalis stage when it had left the victim in which it had germinated, fed and grown.

There then are two distinct living organic beings, one animal and the other vegetable, both enclosed in another being, also animal, organic, and living, which is to serve them as food for their development and subsequent growth. When the common food supply in the dead insect containing them ends, the

children or seeds of the vegetable parasite, reproduced and perfected in the corpse, invade the other animal parasite still present in the dead insect, and fulfil their own functions in it, so that the little grub or worm which has previously invaded the other dead one, is compelled to meet the same end as the other insect invaded by both the parasites, one animal and the other vegetable, had already met.

Who knows whether some species of contagions that afflict man are not also vegetable? Indeed I suspect that the *Cholera morbus* is of this nature.

CHAPTER VIII

The many observations and experiments I have made over a long period of years have proved to me that the mark disease or muscardine never arises spontaneously in the silk worm, or in other insects: that it always derives from an external being, which, by entering the insect and developing, causes the disease, death, and subsequent salification of the corpse: that this being is organized, living, and vegetable: that it is a parasitic plant, a fungous production: that this cryptogamic plant develops, grows, and multiplies only in the living insect, and never in the dead, and only in the genus of caterpillars; and it does not fructify, or at least it does not mature its seeds, until the insect that has nourished it is dead[1]: that the disease produced by this fungus, or rather the insect killed by it, is contagious, but never so long as it is alive: that by using the seed of this parasite, man can at will make not only silk worms but also other species of caterpillars fall sick with muscardine and then become calcified, both in the larval, and in the chrysalis and moth stages, and constantly in all seasons, and can transport the cruel disease from one place to another and even cause it to migrate to distant regions: that with the same seed, one can communicate the mark disease, should one so desire, at the same time to silk worms that are entirely different in age, in origin, and by food and breeding and other circumstances; and make silkworms in one room fall ill with the disease, while leaving those in another untouched, though they all originated in the same place and in the same manner, and from the same premises and in the same way: that one can also, by means of the seed in question, even make a whole brood die of muscardine, by spreading the disease-bearing germs amongst the eggs. If these and other things that I have already mentioned, and still others that I omit for the sake of brevity, can be achieved by means of the fungous seeds whenever one wishes, it seems that no doubt remains as to the contagious substance of the disease in question.

That the mark disease or muscardine is really contagious in character, nearly everybody is now convinced, despite many facts indicating the contrary which breeders, who are unacquainted with the theory of this contagion, are unable to explain to themselves what they see or hear from others[2,3]. But it is difficult, moreover, to persuade breeders and even not a few savants that the disease in question does not arise spontaneously in the silk worm.

Reason and experience teach us that the substance that grows and rises up in several ways on the surface of the corpses of insects which have died of the mark disease, if it is introduced by inoculation, by contact, or with food either into silk worms or into other caterpillars, produces the disease, death, and subsequent calcification.

To convince oneself and others that the disorder of which we are speaking does arise spontaneously in the silk worm, i.e., that it originates for some quite different reason than the said parasite, although it may subsequently propagate itself by contagion, it is essential to know how to produce true muscardine, such as is obtained by the use of the said plant or substance, whatever it may be, in some way, if not in other caterpillars, at least in the silk worm, or else to be able to prove that the mark disease occurs independently of the parasite mentioned, or without the presence of the said substance. And this will never be done, in view of the immense quantity and multiplicity and the high degree of divisibility and diffusibility of this substance, which can be carried in all ways, even by flies and other creatures, and by the movement of the air itself. That being so, everyone can see that the only remaining possibility is that the phenomenon may be brought about by some other cause or substance besides that which causes it before our eyes, at will, and constantly, and not only in silk worms but in almost all other worms, and which, if it is passed through a long series of species of these insects and is again introduced into the silk worm, is always the same[4].

The great rapidity with which the mark disease spreads amongst silk worms after their fourth moult, and the great havoc normally wrought by the cruel disease amongst the precious insects at this age, makes their breeders think that the disease arises in them spontaneously, since they are unaware of the causes of the occurrence[5].

Even supposing, moreover, that the disease does arise spontaneously, it ought in that case to develop as the result of some other cause than bad food, lack of cleanliness in the breeding rooms, or the various fumes that emanate from the fermenting litter. In the district round Lodi, where irrigation and the fertility of the soil render the atmosphere very damp and the leaf moist, and where the peasants' houses which are used as breeding establishments are for the most part low, narrow, and ill ventilated, and where generally speaking the silk worms are badly kept and were even worse kept in the past, no one even knew what the mark disease was; whereas in S. Colombano, situated in the same province, it has long been known, because the dry air and the crisp leaf of those hills make the muscardine contagion more vigorous and the silk worm more suitable for feeding it and reproducing it, so that the malady appears there from time to time, and sometimes also displays its ferocity there. The cruel muscardine, far from attacking weak, unhealthy worms and those lying on a bed that is high, very damp, soaked, or rotting, normally prefers to attack silk worms that are healthy, robust, well-nourished, and well-tended—or rather tended according to the ordinary precepts of most writers and of the

so-called *bigattieri* in general. Now if the disease originated from the various effluvia that arise in the silk worm breeding establishment, or if it came from air contaminated in some way around the silk worm, or from bad management, or from the state of captivity to which man subjects the useful insect, the disease or rather calcification would not be common to other species of caterpillars, which are attacked by it in the open air in their natural state. But how on earth, it will be asked, can the muscardine germs come in contact with such insects which live in the open country? And does ingenious nature lack means to carry such light and numerous seeds on the wings of the air and chiefly of the wind to the various bodies, and to maintain some alive until they have access to one worm or another and, entering it, [can][6] germinate, feed, and reproduce themselves?

I am inclined to think that the disease of which we are speaking did not arise spontaneously, even when it appeared for the first time on this earth and killed the first silk worm or other caterpillar. The seeds of the vegetable parasite appeared on the planet at the same time as caterpillars or after them, were introduced or carried into them in some way by the very hands of nature herself, and could thus develop and reproduce themselves there; and the new seeds generated, passing on to other creatures or caterpillars, were able to repeat the functions of their parents, causing, that is to say, the disease, the death, and the subsequent calcification of the insect invaded, and, by procreating other beings similar to them, to continue from generation to generation to carry out the same functions, as they are still doing, and as they will also do in the centuries to come, as long as there are muscardine seeds capable of developing and worms to offer them, when they are invaded, food suitable for their growth and reproduction.

And supposing, moreover, that this disease did arise spontaneously in our days, no one will ever be able to say that it is constitutional, since it never attacks a whole district all at once and at the same time, as constitutional diseases do; but, beginning normally in a small way, it passes from one silk worm establishment to another, and so from one building to another, until it finally infects a whole commune, in the manner in fact of all contagious diseases, which begin in one spot and gradually spread until in this way they become epidemic and infect great areas and sometimes whole provinces.

Those who maintain that the contagious germs are inorganic bodies, and perhaps also those who wisely say that we do not yet know the elements of the contagion, will object that the contagious virtue, or the power of transmitting the same disease to other insects, does not belong to the organic being mentioned by me, but to the underlying animal substance of the dead insect, or to some other substance joined to the living plant. But if the muscardine contagion does not consist of the reproduction of the fungus, why is there no contagion in the corpse where there are no seeds of the plant, or where they did not reach maturity, or were removed or destroyed? Why, if the germs of the parasitic plant are debilitated when they enter the insect which they are invading or are unable to repro-

duce themselves for some other reason, can the being that contains them, although it succumbs to their vegetative power, not produce in other insects the same disease from which it perished, from lack of new perfect seeds? Why, if the contagion resides in the dead animal substance and not in the living substance, why, when it is separated from the insect in which it has been produced, does it remain active for a longer time, and why, if it is placed in water, does it retain its contagious virtue, in other words, its germinating property, for many days, and even for over a month, if it is left on the surface of the liquid, for of itself it does not sink; whereas if the corpse from which the same substance or seed was taken is placed there it soon loses all its power of communicating muscardine?

If experience teaches us that the muscardine dust preserves the contagion longer in isolation than if it is attached to the salified worm; if the same dust, rising into the air, generates the mark disease in the silk worm if it alights on it and invades it, or falls on to the leaf that it is eating; if the white or efflorescent part of the calcified larva or chrysalis remains contagious longer than the part that is coloured, i.e., that has not turned white, even though it be taken internally: it must be concluded that the disease reproduces itself with the reproduction of the parasitic fungus, and not otherwise.

Considering that the particular acid substance that is formed or released in the insect killed by muscardine and that then hardens and salifies it, reveals its free presence to the needle at the same time as the contagion appears in the corpse, i.e., soon after death, some might still suppose that the contagious principle is present in this dead substance rather than in the other organic and living substance. Although many reasons may be adduced against this hypothesis, it is enough for me to mention that the acid substance is sometimes present without the contagion, which has already disappeared or which has not been generated, as occurs in some muscardine black corpses, which, although they turn a needle rusty, do not possess the muscardine contagion; and the contagious principle is sometimes present in the corpse without the acid, even though the corpse has not yet turned hard, and always, moreover, when the acid substance having combined with some other substance, salifies the dead insect and, therefore, gives no further sign of its free presence to the needle.

It must further be added that, whatever the inorganic substance which is claimed to generate the disease in question may be, whether acid or otherwise, since it is endowed like any other contagion with the reproductive power, it can only be regarded as a yeast or ferment, and as such it would not always be identical and operative if it were diluted in a great deal of water; nor would it be entirely destroyed or deprived of its procreating virtues by agents capable of decomposing or of injuring the organism, whether vegetable or animal, and not the fermenting principle, as I shall explain more fully in the practical part of this work.

Finally, whether the mark disease arises spontaneously or not, or whether the substance which produces it is organic or inorganic, it is

certain that, if not always, nearly always, or at least on most occasions, the cruel disease must be caused and spread around by contagion, particularly in view of the rapid and boundless increase of contagious germs and the ease with which they quickly spread, provided they are dry, on to all surrounding bodies and into the air itself, one single efflorescent silk worm being sufficient to produce and spread around several millions of disease-bearing germs. Therefore, a book that teaches one to know the principle or the substance, whatever it may be, which generates the terrible disease, and to keep the substance from one's own breeding establishment, and also to destroy it if it has unfortunately got into the breeding rooms before it becomes harmful, not merely on the various objects contaminated but even on the body of the silk worm itself and inside it, too, in the first passages of its skin: a book that shows how one can prevent the contagious germs from reproducing or fertilizing themselves or at least from spreading around, and that, lastly, enables anyone to institute all possible experiments relating to the question with the certainty of not drawing erroneous conclusions from the respective results, a certainty which in the past we could never have since we were not certain of the presence of the mark disease in the insects used for the experiment, as we are now sure, after communicating the contagious principle to the living insect by contact with the fatal dust, and particularly by inoculation—this book cannot, therefore, but benefit the public, even disregarding the various instructions it gives concerning the other parts of the management of the precious insects and other useful information contained in it.

Leaving, therefore, to the learned and the intelligent the task of recognizing the truth of the theories set forth by well devised and repeated experiments, and even of amplifying them as far as possible in the interests of science, I shall undertake in the second part of this work to show breeders by what means one can preserve silk worms from muscardine or at least greatly lessen the heavy loss which it inflicts on the individual and on the State in general, by now destroying the organism which generates the disease and now keeping it away from the breeding rooms according to circumstances, which is what it is above all important to know.

Human smallpox, whatever its origin and the nature of its germs, and whether it reproduces itself by pure contagion or arises spontaneously, ceased to rage amongst us when the inoculation of the vaccine, by vastly reducing the number of sick, decreased that of the disease-bearing germs even further. Similarly, muscardine will cease to wreak havoc amongst silk worms when breeders collectively carry out the disinfecting, curative, and preservative method which I suggest and recommend. Disinfection can be achieved in several ways, by the use of several agents, i.e., by many substances, by fresh air, and with time; the disease can be cured by removing the silk worm from the prevalent contagion, in other words from the mass of disease-bearing germs, by rendering it less suitable to receive, feed, and reproduce them, and by destroying the germs on its body and inside the first passages of it; and the disease can be prevented

by the thorough purging of the rooms and of all contaminated objects, and by preventing both the reproduction of the muscardine germs in the breeding rooms and a fresh invasion from outside into the breeding establishment, all of which I shall explain fully in the second part of this treatise[7].

FOOTNOTES

[1] I beg the savants of Florence, indeed De Amici himself, to look at the individual muscardine germ with his very powerful microscope, if it is possible, being convinced that with this unique instrument one may be able to detect its shape or learn its true nature better. To be successful in this, some silk worm chrysalises should be inoculated with muscardine and placed as soon as they are dead in a dry place, being turned over frequently so that they do not effloresce. Then, when the mummy has turned hard but not white, other chrysalises should be inoculated with it, so as to make sure that it is contagious; and then the point of a fine needle should be stuck into it or merely rubbed on it, and the glass which is to be used for the experiment be touched with the needle, so that the disease-bearing germs which are to be observed through the microscope are deposited on it.

Although nothing can be seen on the needle with the naked eye, nevertheless, muscardine seeds must be present on it in large numbers, since if one inoculates several chrysalises in succession with the same needle, without taking new contagion from the mummy, all fall sick with muscardine and perish, even though the animal humour of the various insects inoculated, by washing the point of the needle which wounds them, and even more the friction against the skin which is pricked, make the needle lose a large proportion of the pestiferous germs on it.

Another fact shows the extreme minuteness of these germs and their presence in large numbers on the point of the needle. If one takes the end of the needle between two fingers with paper or a piece of linen or something else and one turns or rolls it, without however changing its position, and if one then inoculates or merely touches a silk worm, the disease is still communicated to it, although a large part of the muscardine seeds have remained attached to the paper or cloth with which the needle was wiped. But if, in cleaning or rubbing the contaminated needle in that way, it changes its position several times, then both touching and inoculation are quite harmless to the insect, because the needle no longer contains disease-bearing germs, or retains so few that they are not sufficient to infect the insect.

Who knows whether, if the individual plant is examined with the microscope mentioned above, the locomotive faculty will not be discovered in it, and the eye will not observe an animal instead of a plant? This at least is not impossible: other productions of nature which were believed to be vegetable have been subsequently recognized as true animals; and recently the flowers of wine, beer, etc., and conserves were declared to be such as the result of the ingenious observations of the celebrated Messrs. Desmazières of Lille, and Chauvin of Caen. Who knows whether the parasite in question, although it reveals itself in the form of a plant, is not an animal, since it seems strange that a plant should owe its existence to an animal which it invades while it is alive, and which it then kills in order to fructify and to reproduce itself subsequently in other animals of the same genus as those in which it was itself generated.

[2] Sic (Translator's note.)

[3] One of the phenomena, and perhaps the chief one which makes breeders loath to believe that the disease is contagious, since they lack the necessary knowledge to explain to themselves what they see, is that sometimes presented by a so-called double cocoon, in which one observes that one chrysalis has perished from the mark disease and been calcified, while the other has turned into a moth and emerged. That may happen for several reasons, although the disease which has killed one of the two insects enclosed is by nature contagious, as I have said above.

The worm infected by muscardine which shuts itself up in the cocoon together with another healthy one, cannot infect it with the same disease before it dies, since the muscardined insect does not become contagious until it is dead and particularly until it has turned white. It follows: First, that its companion, having in the mean time passed into the chrysalis state, cannot easily be infected with the mark disease by mere contact, on account of the hardness and lack of porosity of the membranous sheath which contains the chrysalis, as my experiments prove; Second, that even if it absorbs the deadly contagion, since it can only be invaded by it when its metamorphosis is imminent, it can not only change into a moth even though it is infected by muscardine, but even sometimes help to multiply the species before death kills it.

From what I have said hitherto in this work, it can be seen that the calcified worm is highly contagious, and that a minute particle of it, although invisible to the naked eye, is enough to infect a healthy silk worm and cause it to die of the mark disease. Bearing that in mind, everyone can easily imagine what a boundless and infinite number of disease-bearing germs is contained in that dust which rises like a cloud before our eyes when we shake or move in any way the wood or paper used to rear the silk worms in a breeding establishment afflicted by the cruel disease: as everyone can easily imagine how great the dissemination of the same disease around must be, not only in the breeding-rooms of the same proprietor, but also in the premises of neighbouring breeders, and even in the whole district and in the communes nearby because of the many exchanges of all kinds which take place between two neighbouring districts: and, therefore, everyone can clearly understand why the terrible disease spreads so much and wreaks such havoc amongst the valuable insects, and why it must of necessity wreak even greater havoc in future, as long as its operative seeds are left uncombated and human skill places no obstacle in the way of their reproduction or of their diffusion.

[4] Like the large fungi that are commonly believed to arise spontaneously from the soil, and not from seeds, this parasite, which must belong to the smallest species of fungi, by scattering its seeds, chiefly on the wings of the wind, goes in search of a suitable spot, i.e., of caterpillars, in which to develop, grow, and reproduce itself, in the same way as the fungi of the larger species, whose seeds do not vegetate wherever they fall, but only on favourable ground: and the warm and dry season which perfects the latter and renders the soil more suitable for their development, makes those of the tiny parasitic fungus more active and the silk worms more able to receive, develop, nourish, and reproduce them.

[5] The principles deduced by me from so many experiments and set forth here in this work will have already made the reader acquainted with the sources from which the phenomenon derives: however, I think it may be as

well to set them forth briefly here together for the greater edification of the public.

It is very rare for the muscardine contagion to enter a breeding establishment after the fourth moult. It is almost always present there first in the preceding ages, though it is often unnoticed; and then, as the disease-bearing germs increase continually with the increase in the number of dead insects that have turned hard and more particularly of those that have turned white, it is only natural that after the fourth torpor, i.e., when the silk worms have reached their fifth stage, these germs must in the natural course of things increase the number of victims because of the progressive increase in the number of dead and calcified worms, quite apart from the other causes which help to increase the number of contagious germs and to make their invasions even more frequent at this period. But whether the mark disease develops before or after the fourth moult, when the fatal germ is in some way introduced among the silk worms, how can it be expected that after the fourth moult the number of insects infected with muscardine, will not greatly increase, if the number of attacking disease-bearing germs is normally much greater in the fifth stage for the reasons given above, their vigour greater, and the points of contact between them and the insects bred more numerous, quite apart from the fact that their quantity is greater, the invasions are easier and more rapid, the period of the disease is shorter and reproduction more rapid and more frequent; if the organisms reproduced are even more numerous in every single reproduction, so that a worm invaded by the deadly parasite, even after it has undergone the fourth moult, has time to reproduce the contagion, especially if it is of the most malignant variety, and to communicate it to its brothers and sisters before shutting itself up in its cocoon, and these may sometimes infect yet other worms with the germs reproduced in it before secreting the silky humour; and if between the fourth moult and the production of the cocoon, the muscardine seeds can reproduce themselves as many as three times? In view of the extreme fecundity and multiplicity of the parasitic plant, everyone can clearly appreciate the immense quantity of contagious germs with which all bodies present in the breeding room must be covered and which must be scattered in the very air at the stage of which we are speaking, especially as it draws to a close, and all the more so if many have been formed and scattered in the previous ages: and every invading germ at that period produces a more numerous and vigorous progeny in the insect invaded, and few, indeed very few, of the invaders at this time fail to reproduce themselves, making the disease sporadic and the corpse, therefore, unable to communicate the cruel disease to other worms.

The atmospheric heat, which increases as the season wears on, increases the strength of the germs, and, the leaf having become more mature and firmer, the aqueous principle in the silk worm diminishes, and the acid, earthy and alkaline substance or that of their components increases, thus making it more suitable to nourish and reproduce the contagious germs and to provide more and more numerous and potent successors.

The greater volume attained by the worms at the age in question, and the greater surface of the leaf which they touch and on which they feed increases the points of contact between them and the disease-bearing germs, quite apart from the increase in the number of germs, and this contact is also increased by the greater circulation of the internal air caused by the fact that they take up more room, and by the extra work necessary at this period, especially

where it is customary to maintain only mild ventilation in the silk worm establishment, even after the fourth moult of the silk worms, instead of flinging open the doors and all the windows, and all the other apertures there are—which maximum ventilation, while it makes it easier to keep the silk worms healthy and vigorous, also helps to make the formidable muscardine less deadly in several ways. Moreover, if this increase of contact makes the attacks more frequent, the greater energy of the muscardine germs together with the greater ability of the worms to develop, feed and reproduce the contagion, makes the invasions easier and more rapid, and hence the period of the disease shorter, and reproduction more abundant, and the number of insects which perish and are calcified greater—and therefore the number of contagious germs even greater and growing, and consequently the number of insects touched and invaded greater, that of the sick and dead greater, the destruction greater; and the cruel disease meanwhile, assuming epidemic form, displays its greatest ferocity to the detriment of present and future generations, often devouring whole broods.

In addition to the causes mentioned, the old and new germs which have at other times been ineffective from extreme weakness or some other defect inherent in them, are invigorated at this season by favourable circumstances, become active and lethal in their turn, and help to increase the number of victims and produce the tremendous disaster.

And if it sometimes happens that after the fourth moult, the mark disease already raging diminishes instead of increasing and sometimes even ceases almost entirely, without human intervention, it is because the causes or circumstances which have started or spread the disease decrease or disappear, or because chance brings agents which check the further progress of the cruel disease.

A change of food; pure, uncontaminated food substituted for leaf coming from districts where the mark disease is raging and placed in infected sacks, recipients, or premises, or plucked, distributed or otherwise touched by persons who are infected or otherwise contaminated; a leaf which is tender and moist, because of the species or variety of the mulberry or of the youth of the branches from which it has been taken, or because it is less mature or rather because of the quality of the soil, fertile, well-watered or otherwise damp, which has nourished it, provided after a leaf which was firmer and harder because it was of a different species or more mature, or because it came from a poor, arid, flinty soil; a considerable drop in the temperature; heavy and prolonged rainfall; a sirocco or sea wind, following a dry northerly one; leaf wet with rain or gathered with dew on it or given to the silk worms as soon as it is plucked or detached from the tree, instead of giving it, as before, after it had been kept for some days; the atmosphere of the breeding establishment made excessively damp because it is kept tightly closed, or because water has been spilt on the floor, or because wet leaf has been introduced, or from some other cause; the breeding room much better ventilated because all the apertures have been opened wide; the deliberate removal of contaminated paper or trays—these and other causes are capable of weakening and sometimes even of destroying the muscardine germs, or of rendering ineffective those which might otherwise have been active, and of making the silk worm less suitable for feeding and multiplying the contagious seeds in it. The fewer the reproductions, the fewer the germs reproduced in each generation, the more numerous the insects which die of the black disease, the fewer the

calcified ones, the fewer the disease-bearing germs which detach themselves from the corpses that have turned white, because they dry up less, or less rapidly, and therefore, the fewer the newly diseased insects and the germs reproduced, and the proportion of lethal ones amongst these is very much smaller.

The changes of things and circumstances mentioned and other variations may produce these and other effects, all tending to diminish the terrible disease in some way to a greater or lesser extent, and sometimes even to put an end to it if it is combated by many opposing causes* at once.

[6] Omitted in the text. (Translator's note.)

[7] Since I have spoken at great length in this work of a singular cryptogamic plant which feeds only on animal substance and assumes the first rudiments of its active life only in the living animal organism, never in the dead one, it is more fitting that I should express an opinion of mine regarding another no less wonderful cryptogamic plant which, on the contrary, develops, grows and spreads only in dead animal substance. I refer to that wonderful plant to which we owe, in my opinion, the preservation of many human corpses, in other words the conversion into natural mummies of the dead bodies of our species, particularly in the tombs of Venzone, of which Dr. Marcolini treats in a memoir printed in Milan in 1831.

I am of the firm opinion that the drying up or transmutation into spontaneous mummies of the human bodies in those tombs is entirely due to the vegetative act of the cryptogamic plant or fungus which covers the said corpses, whose germs, once they have somehow succeeded in touching a corpse in circumstances favourable for their development, prevent it from putrefying by transmuting the dead animal substance into living substance, i.e., into their own substance. Hence, when the coffin or other recipient which contained the dead person has decayed with the passage of time and the corpse been exposed, the very numerous and tiny seeds of this fungus spread around and even rise into the surrounding air, especially when it is agitated by the reopening of the tomb, and can** easily come into contact with the new human corpses deposited there, by introducing themselves into the small apertures or cracks of the coffin or other vessel which contains the corpse, particularly if there is an extravasation of liquid animal matter which has access to the outside air. The tiny germs of the fungus in question cling to this and the little plants germinate there and reproduce themselves rapidly and in large numbers, by seeds, by branching, or by ramification; they quickly take possession of the whole corpse, invade it and cover it completely, converting the dead animal substance into living vegetable substance, and thus preserving the dead man from corruption, whose corpse then gradually dries up and is converted into a natural or spontaneous mummy. And in my opinion, the conjecture of the illustrious compiler of the article inserted in vol. 63, page 204, of the Biblioteca Italiana was correct.

This cryptogamic plant, like the muscardine plant which solidifies and preserves silk worms and other insects, draws, in its vegetative act, from the animal that contains it and perhaps also in part from the atmosphere, the

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* Sic. (Translator's note.)

**The original has *può* in the singular, either by an oversight, or referring to the fungus; but the sense seems to require the plural, referring to the seeds. (Translator's note.)

elements necessary for the formation of the acid substance that salifies and desiccates the corpse of the dead person, laying bare the aqueous principle which, being isolated and unable to promote putrefaction in the dead animal substance, is compelled to yield to the affinity of heat, which gradually appropriates it and evaporates it.

If that does not exactly correspond to what happens in the conversion of human corpses into mummies of which we are talking, it is what is seen and observed at least in the various phenomena brought about and analysed by the experimenter in connection with the calcification of silk worms and other worms. The fungus in question vegetates on the dead animal, unlike the muscardine fungus which makes the first movements of its growth only in the living insect. Like the muscardine fungus, however, it salifies, desiccates, and preserves the dead animal substance.

If anyone wishes to know whether the phenomenon, i.e., the conversion of the corpse into a spontaneous mummy really proceeds from the vegetative process of the fungous plant mentioned, let him take some of the dust, i.e., that white substance that covers the Venzone mummies, but let it not be too old, and let him rub several human bodies of both sexes, and particularly ones that are not very moist and that have died of diseases which do not hasten putrefaction, lightly with it as soon as they are dead, and then let him place them immediately in several tombs, including those of Venzone, enclosing some in coffins or other vessels and leaving the others uncovered. Let them be placed also in genuine underground vaults that are damp to a greater or lesser degree, both at Venzone and elsewhere, and let that be done at various times, in spring, in summer, or in autumn, and with dust or germs of different ages taken from mummies of six, eight, twelve, and sixteen months and more.

The germs of the said fungus that transforms and preserves the dead animal substance must, if they are placed in contact with the substance capable of developing and feeding them in favourable circumstances, develop and grow and then reproduce the tiny plants by seeds, by branching or ramification, and thus solidify the dead animal substance and convert it into their own living, vegetable substance.

I therefore invite physicists and doctors particularly to try the experiment, so that they may be able to discover, if it is possible, the true cause of such a wonderful phenomenon, and to preserve uncorrupted the bodies of those who have died, whose memory must on various counts be very dear to us.

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